MECHANICAL DRAWING AND PRACTICAL DRAFTING

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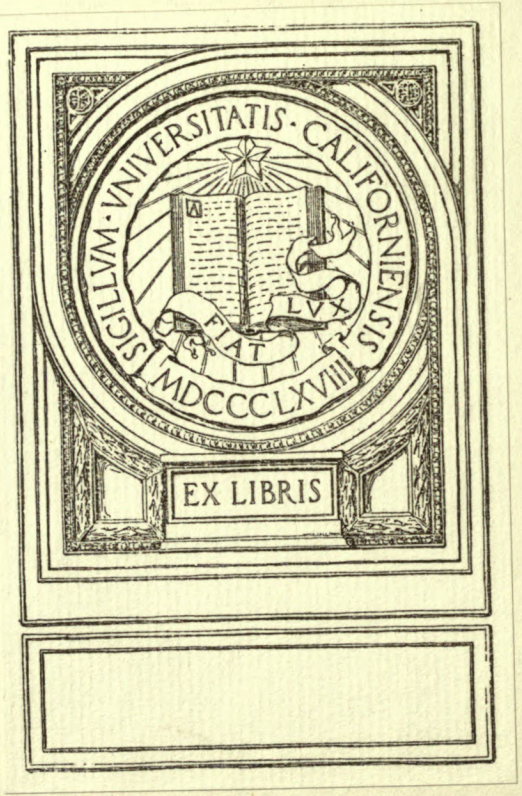
CHARLES H. SAMPSON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MECHANICAL DRAWING AND PRACTICAL DRAFTING

By

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Author of "Algebra Review," "Woodturning Exercises," "Assignment Manual of Algebra," "Pattern Making," and various courses for the University Extension Department.

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MILTON BRADLEY COMPANY
SPRINGFIELD - MASSACHUSETTS
1920

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PREFACE.

Although there are many excellent works on the market covering in a more or less complete way the subject of Mechanical Drawing and Practical Drafting, it has been my experience that most of these are not sufficiently extensive and practical to admit their use in schools where it is necessary to devote a large amount of time to the subject, or in classes composed of men wishing instruction of a practical nature. The course as herein presented has proven its worth, and large numbers graduated from it have experienced no difficulty in securing and retaining drafting positions. Sufficient ground is covered in the elements of Mechanical Drawing to insure a solid foundation for the work of a more practical nature following.

I hope that this book will prove to be all that I think it to be. I am exceedingly anxious to make any desirable improvements, and would therefore welcome suggestions from either the teacher or the man in the office.

Several important changes have been made in this edition. Material has been added which should improve the course presented, and every effort has been made to make the work as it should be. It is hoped that these changes and additions will prove valuable to both the teacher and student and add greatly to the efficiency of the book as a means of properly imparting a knowledge of the subject which it represents.

This text is especially intended for use in the class room. Every effort has been made to produce an ideal text for this purpose.

Respectfully,
Charles H. Sampson.

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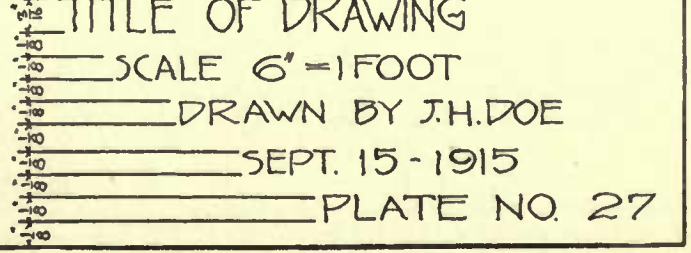
THINGS A GOOD DRAFTSMAN SHOULD REMEMBER.

(READ CAREFULLY.)

Be neat and accurate, and keep busy. Study the problem before attempting its solution. Don't be afraid to ask intelligent questions. Keep the pencil sharp and the instruments clean. Always clean a pen before using. Use the T square by placing the head on the left hand side of the board. Use the triangles against the T square. Become familiar with the use of the scale as soon as possible. Practice lettering continually. It is well to learn to make both the slant and vertical types, but it is better to be good at one than just fair at either. The general appearance of a drawing depends largely upon the lettering. Always make a pencil drawing complete, even though it is to be inked or traced. When inking or tracing a drawing, draw the lines in the following order: Center lines (very light, dot and dash); all arcs and curves; full straight lines; dotted straight lines; cross section lines (45 degrees when possible); arrowheads; dimensions; lettering; border line and title. Make dotted and center lines lighter than the others. The drawing should always be checked before being inked or traced. The title should include the name of the object drawn, the scale used, by whom drawn, the date finished, and the number of the drawing. Learn to make sketches from actual machine parts, and remember that a sketch isn't worth much unless it is properly dimensioned. Before starting to trace a drawing it is well to rub the cloth well with "ponce" or powdered chalk. When erasing use a pencil eraser, especially if the surface is to be inked over again. Erase lightly. Make shade lines by drawing several lighter ones. Dimensions under two feet are usually expressed in inches; those over two feet in feet and inches. Make the sheet balance. Draw to as large a scale as possible.

GENERAL INSTRUCTIONS (READ CAREFULLY)

ALL SHEETS TO BE $14\frac{1}{2}" \times 20\frac{1}{2}"$ OUTSIDE DIMENSIONS UNLESS OTHERWISE SPECIFIED. ALL MARGINS TO BE $\frac{3}{4}"$ WIDE UNLESS CALLED FOR DIFFERENTLY. ALL TITLES ARE TO BE PLACED IN THE LOWER RIGHT HAND CORNER AND ARRANGED AS BELOW. DO NOT INK OR TRACE A DRAWING UNLESS INSTRUCTIONS CALL FOR SUCH WORK. DO NOT PLACE THE DATE UPON THE DRAWING UNTIL IT IS FINISHED. DO NOT INK INSTRUCTIONS ON ANY SHEETS. FOLLOW DIMENSIONS. NEVER SCALE A DRAWING WHEN INKING LETTERS MAKE ALL STROKES DOWN (O) OR TO THE RIGHT E. MAKE ARROW HEADS LIKE THIS > NOT LIKE THIS). FORM ALL LETTERS AND FIGURES SO THAT EACH WOULD FILL A PARALLELOGRAM IF PROPERLY CONSTRUCTED A B M S. MAKE FRACTION THUS $\frac{3}{8}"$; MIXED NUMBERS $5\frac{1}{8}"$ FEET ARE REPRESENTED BY ′; INCHES BY ″. 2′-6″.



THE LETTERING PLATES.

Only two lettering plates are required. Both of these have been selected because the letters represented are the types in most common use. The first plate shows the vertical and slant styles of letter generally used by the draftsman on detail drawings; the second plate represents a type much used for titles.

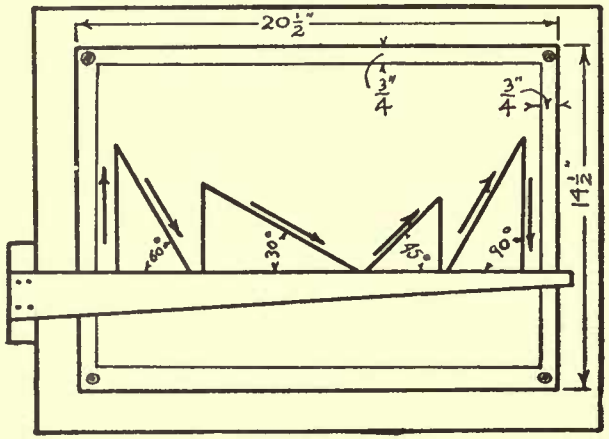


Fig. 1

There are, of course, very many forms and kinds of letters. It has been thought best in this course to require only those covered by the first two plates, hoping that by so doing at least a reasonable degree of perfection may be attained in these most generally used types.

One may obtain many excellent books on lettering if occasion demands some particular style.

The student will make use of the board, T square, triangles, scale, pencil, and eraser during the progress of Plates 1 and 2.

Figure 1 shows how the T square and triangles should be used. Note that the head of the T square is against the left hand edge of the board. Also notice that all vertical lines and lines making angles with the horizontal are drawn using the triangle against the T square. Vertical lines should not be drawn using the head of the T square on either the upper or lower edges of the board.

Other instruments employed during the progress of the first two plates, as well as all of the others, are the scale (ruler), eraser, and pencil. The scale is to be used for measuring purposes only and is not to be employed as a guide for drawing lines. The triangles are to be used when lines are to be drawn as indicated. Become familiar with the use of the scale as soon as possible.

Fig. 2

Fig. 3

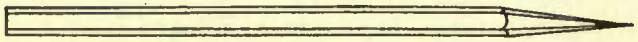
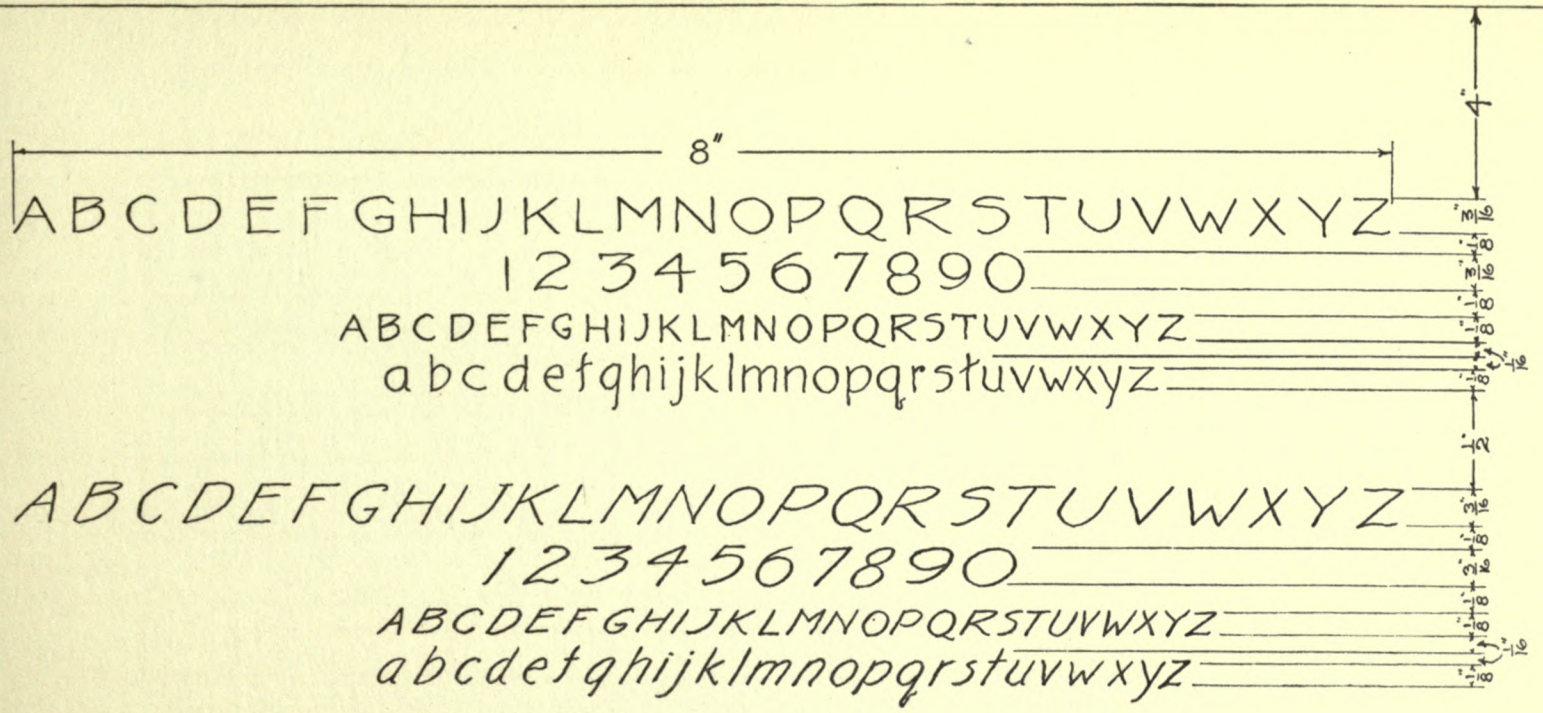


Fig. 4

Erasing is more or less of an art. When it becomes necessary to erase, use a pencil eraser. The resulting surface will then be smooth. Cultivate a light touch. That is, do not "bear on" too heavily when erasing. Every student should have a cleaning eraser for use in cleaning dirt and surplus lines from the drawing. "Art Gum" is recommended.

Great care should be observed in the matter of keeping the pencil sharp. If a fine round point is always kept on the lead it may be used for both lines and lettering. Some prefer a chisel point for use when lines are to be drawn. It is suggested that the pencil be sharpened at both ends. A point is then available for all purposes because one may be made a chisel point.

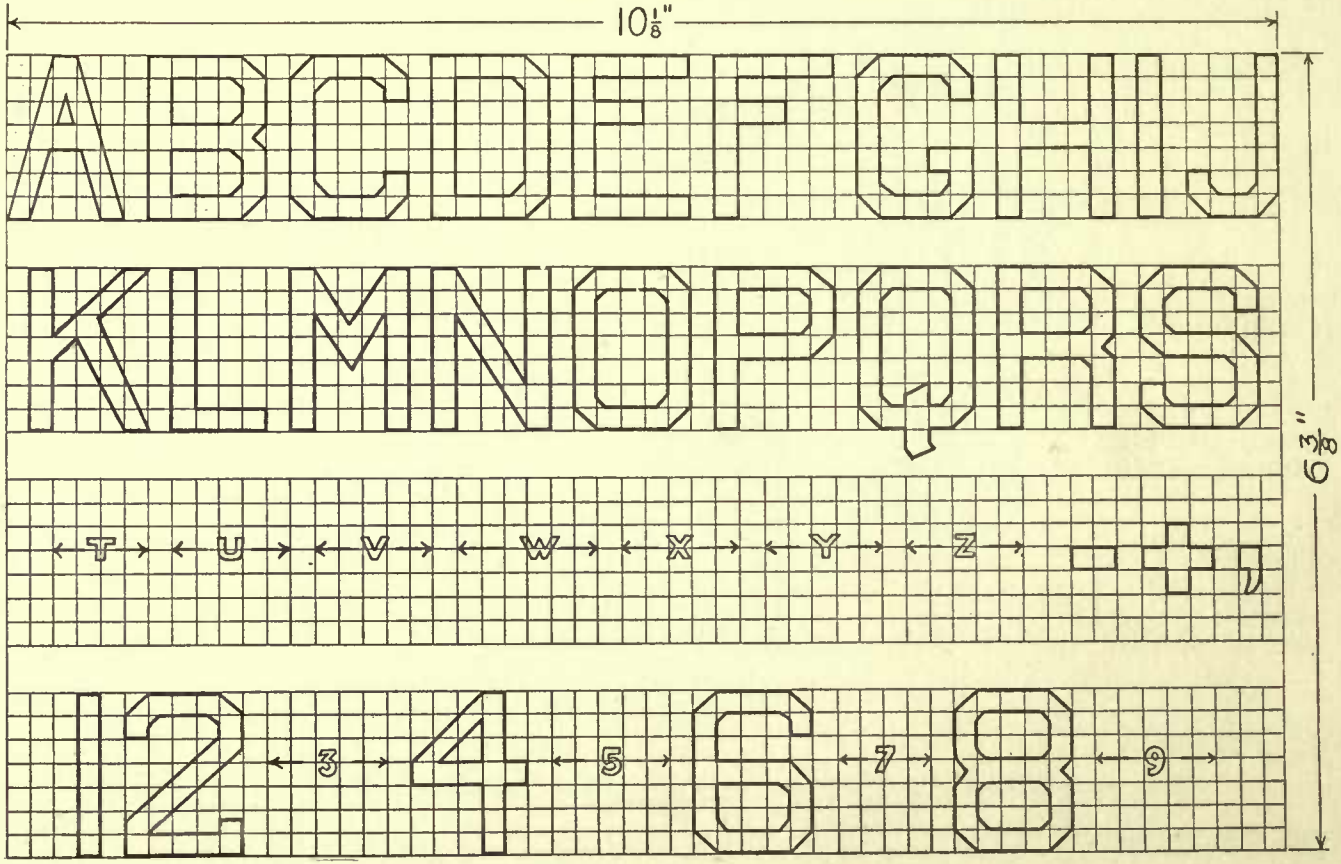


INSIDE BORDER LINE

Instructions

The top guide line of the first alphabet is down 4" from the inside border line. Follow dimensions for other lines All lines of letters must be centrally located.

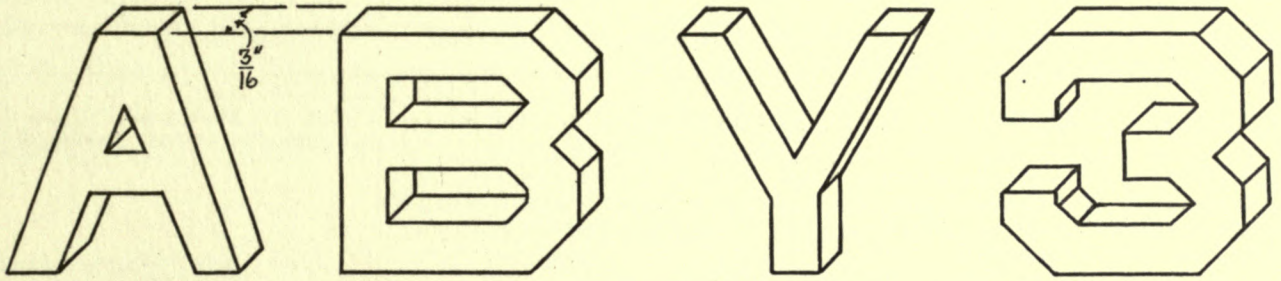
LETTERING
SCALE FULL SIZE
DRAWN BY
DATE
PLATE No 1



INSIDE BORDER LINE

Instructions Draw a rectangle, centrally located, whose dimensions are 6"×10⅛". Divide this rectangle into $\frac{3}{16}$" squares and connect points as shown in forming the letters. The vacant spaces are to be filled in with the letters designated. Finish this plate as described on page 9
The small letters and figures T, U, V, W, X, Y, Z, 3, 5, 7, and 9 are to be drawn full size.

LETTERING
SCALE FULL SIZE
DRAWN BY
DATE.
PLATE No. 2



Instructions The letters and figures on PLATE 2 are to be shaded as shown above. Note that the shading measured on a 45° line is $\frac{3}{16}$" wide.

GEOMETRICAL PROBLEMS

All geometrical problem plates are of the standard size ($14\frac{1}{2}''$ x $20\frac{1}{2}''$). The space inside of the $\frac{3}{4}''$ margin on plates 3, 4, 5, 6, 7, 8, and 9 is to be divided into six equal parts. Five of these parts are to be used for problems. The sixth space, in the lower right hand corner, is reserved for the title, name, date, etc. Great care should be observed in the solution of these construction problems. Fine lines are necessary for clean, accurate work. The instructor may well add to those given, especially if the students are taking a course in Plane Geometry. These problems are to be done in pencil.

GEOMETRICAL DEFINITIONS.

A straight line is a line such that if any part be placed upon any other part the parts will exactly coincide.
A perpendicular bisector of a line is a line perpendicular to it and dividing it into two equal parts.
A curve is a line no portion of which is straight.
An angle of ninety degrees is formed by one line perpendicular to another.
An angle is the amount of opening between two lines intersecting in a common point. Angles are measured in degrees. A protractor is used for this purpose.
A circle is a plane bounded by a line, called a circumference, all points of which are equally distant from the center of the circle.
Two lines are said to be parallel to each other when they will not meet, no matter how far they may be produced.
The mean proportional between two quantities is equal to the square root of their product.
A square is a plane surface bounded by four equal, straight lines, all the angles being right angles.
A triangle is a plane surface bounded by three straight lines.
A hexagon is a plane surface bounded by six straight lines. In a regular hexagon all of these lines are equal. A regular hexagon can be divided into six equilateral (all sides equal) triangles.
A pentagon is a plane surface bounded by five straight lines.
An octagon is a plane surface bounded by eight straight lines.
A circle is inscribed in a triangle when the sides of the triangle are tangent to the circle.
A circle is circumscribed about a triangle when the sides of the triangle are chords of the circle.
A line is tangent to a circle when it has only one point in common with the circumference.
A right triangle is a triangle containing a right angle. The two perpendicular sides are called legs; the other side, the hypotenuse.
A rectangle is a four-sided, plane figure, all of whose angles are right angles. The adjacent sides are of unequal lengths except in the square.
The diagonal of a square, or other four-sided figure, is a line joining two opposite corners.
A rhombus is a four-sided, plane figure, all of whose sides are equal and whose angles are not right angles.
A trapezoid is a four-sided, plane figure, two of whose sides are parallel. The other two sides are not parallel.

(The above constitute a very small part of the total number of geometrical definitions. They are given because of their relation to the following geometrical problems.)

There are many other drawing instruments to be used by the student after the completion of Plate 2. These are described below.

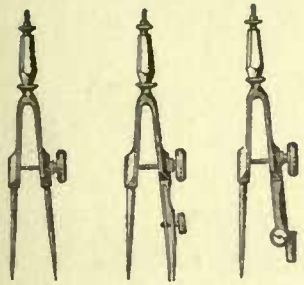


Fig. 1 Fig. 2 Fig. 3

Fig. 1 is a representation of a pair of bow dividers. It is used for spacing off equal divisions on a line. It can be set to a certain dimension and as many multiples of that dimension, as desired, taken.

Fig. 2, called the bow ink compass, is used for the purpose of drawing small circles in ink.

Fig. 3 shows the bow pencil compass. This is used for drawing small circles in pencil.

When a straight line or a curve, not a circle, is to be drawn in ink, the instrument illustrated by Fig. 4 is used. This is called a drawing or ruling pen. Ink is dropped between the nibs from the quill which comes in the drawing ink bottle. To use it, set the thumb screw in such a position as will give the desired width of line and draw to the right for horizontal lines; upward for vertical lines, if line is at left, and down if at right side of paper. (See illustration on page 6.) Always keep the thumb screw outward and slope the pen toward the body.

Fig. 4

When it is necessary to draw large circles in either ink or pencil, the instruments shown by Fig. 5, Fig. 6, Fig. 7, and Fig. 8 are used. The section (Fig. 6) is inserted at A when pencil arcs are to be drawn; the section (Fig. 7) when ink arcs are desired. The extension bar (Fig. 5) is inserted between either of the sections (Fig. 6 and Fig. 7) and the main part of the instrument if one wishes to draw unusually large arcs or circles. The legs of the compass should always be bent so that the axis of the lead or pen is perpendicular to the paper.

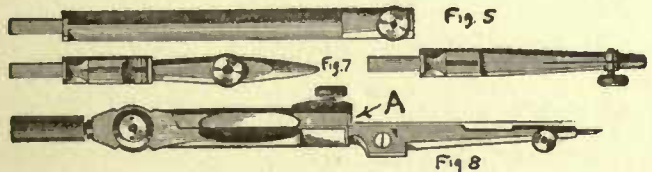


Fig. 6

Fig. 9 shows a longer pair of dividers than illustrated by Fig. 1. This instrument is used for the same purpose as the bow divider and also for transferring dimensions from one drawing to another.

It is quite necessary, if good work is to be accomplished, that the pencil point be always sharp. The sandpaper pad (Fig. 10) is used for this purpose.

Fig. 9

The irregular or French curve is used for drawing a continuous curve, not the arc of a circle. There are many different types of these. A common one is illustrated by Fig. 11. The important thing to remember in the use of this article is that no attempt should be made to draw too much of the curve at one time. Set the curve to correspond with as many points as possible and then draw only a short distance. Shift the curve ahead and draw another short distance.

Fig. 10

Fig. 12 shows one form of erasing shield. This is used to protect nearby lines when a place is to be erased upon.

Fig. 11

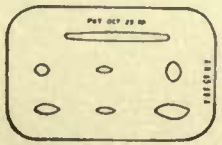


Fig. 12

Just a word regarding paper, ink, and thumb tacks. Use no cheap paper or ink. "Strathmore" detail paper is excellent for pencil work; "Whatman's" hot-pressed for ink work. No ink is better than "Higgins." Thumb tacks are of many sizes and shapes. The ones with a beveled edge are preferable because the T square will slide over them easily.

INSTRUCTIONS.

Problem 1 — Draw any line A B. Using A and B as centers and taking a radius greater than one half of A B, swing arcs intersecting at 1 and 2. Draw the bisector through 1 and 2.

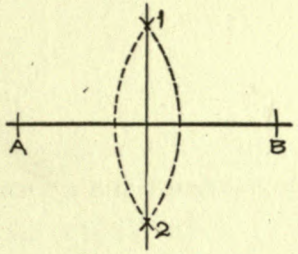
Problem 2 — Draw any arc A B. Connect ends of the arc by the chord A B. Bisect the chord, using method of Problem 1. The bisector of the chord bisects the arc.

Problem 3 — Draw any angle A B C. Taking B as a center, draw any arc 1-2. Taking 1 and 2 as centers and a radius greater than one half of the distance 1-2, swing arcs intersecting at 3. Draw the bisector through B and 3.

Problem 4 — Construct a right angle by drawing A B and B C perpendicular to each other. Using B as a center, swing any arc 1-2. Using the same radius and taking 1 and 2 as centers, describe arcs B-3 and B-4 respectively. Draw the trisectors B-4 and B-3.

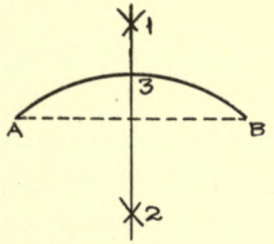
Problem 5 — Draw any line A B and another line A C, making any angle with it. Assume that A B is to be divided into six equal parts, and lay off on A C six equal divisions of any convenient size. Draw 6-B and through the points 5, 4, 3, 2, and 1 on A C draw lines parallel to 6-B. These lines will divide A B into six equal parts.

(Draw the lines parallel to each other by using the triangles—one against the other.)



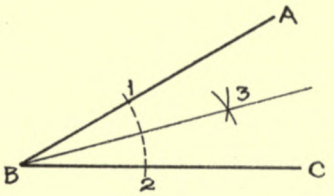
PROBLEM 1

TO BISECT A STRAIGHT LINE



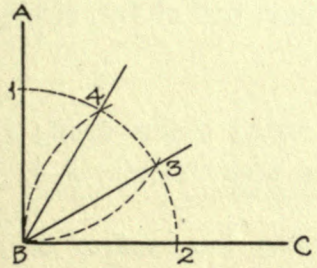
PROBLEM 2

TO BISECT AN ARC OF A CIRCLE



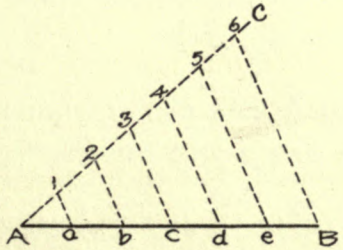
PROBLEM 3

TO BISECT AN ANGLE.



PROBLEM 4

TO TRISECT A RIGHT ANGLE ABC



PROBLEM 5

TO DIVIDE A LINE INTO ANY NUMBER OF EQUAL PARTS.

GEOMETRICAL PROBLEMS

DRAWN BY

DATE

PLATE NO. 3

INSTRUCTIONS.

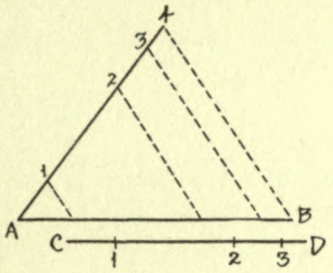
Problem 6 — Draw any line C D and divide it into any number of unequal parts. Draw any other line, as A B, of a different length than C D. Draw A-4, making any angle with A B, and on it lay off the same distances as given on C D. Connect 4 with B, and through points 3, 2, and 1 draw lines parallel to B-4. These lines will divide A B into the same proportional parts as C D.

Problem 7 — Draw any circle. Draw any diameter, as 1-5. Using 1 and 5 as centers, describe arcs passing through the center of the circle. The distances 1-3, 3-6, 6-5, 5-7, 7-4, and 4-1 are equal.

Problem 8 — Draw any line B C, and take any point A above it. Using A as a center, describe an arc cutting B C in two points, as 1 and 2. Taking 1 and 2 as centers and using a radius greater than half of 1-2, swing arcs intersecting at 3 and 4. Draw the perpendicular through 3 and 4.

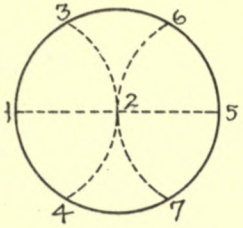
Problem 9 — Draw any line A B. Using A as a center, swing any arc. With same radius swing arcs from 1 and 2 as centers. Using 2 and 3 as centers, swing arcs intersecting at 4. Draw the perpendicular A-4.

Problem 10 — Draw A B, and at any points 1 and 2 erect perpendiculars, using the method of Problem 9. Set the compasses to a radius E F and swing arcs cutting the perpendiculars at 3 and 4, using 1 and 2 respectively as centers. Draw C D through 3 and 4.



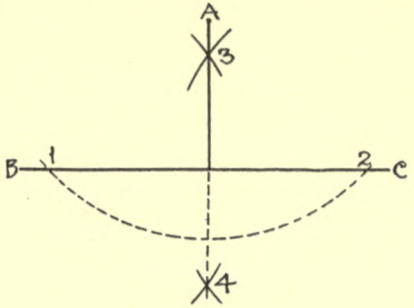
PROBLEM 6

TO DIVIDE A LINE AB INTO SAME PROPORTIONAL PARTS AS CD.



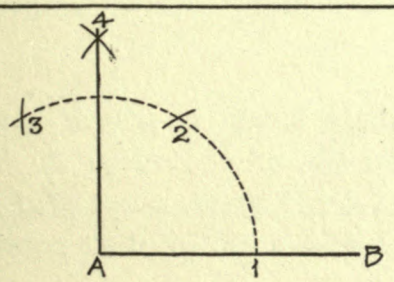
PROBLEM 7

TO DIVIDE A CIRCLE INTO SIX EQUAL PARTS



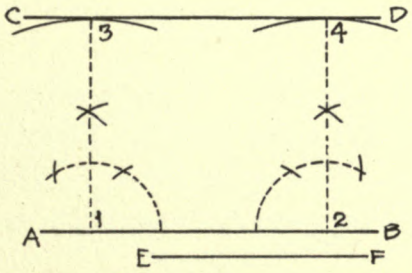
PROBLEM 8

FROM A POINT A ABOVE THE LINE BC TO DRAW A PERPENDICULAR TO BC.



PROBLEM 9

ON A GIVEN LINE AB TO ERECT A PERPENDICULAR AT A.



PROBLEM 10

TO DRAW CD PARALLEL TO AB AT A DISTANCE EF ABOVE IT.

GEOMETRICAL PROBLEMS

DRAWN BY

DATE

PLATE NO 4

INSTRUCTIONS.

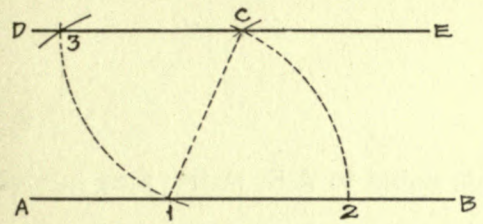
Problem 11 — Draw any line A B and take any point C above it. From any point 1 on A B swing an arc through C. Using C as a center, and the same radius, describe arc 1-3. On 1-3 take a distance equal to 2-C. Draw D E through C and 3.

Problem 12 — Draw any angle B A C. Using A as a center, describe an arc as 1-2. Draw a line D F, and taking D as a center draw an arc having same radius as 1-2. On arc 3-4 take a distance equal to 1-2. Draw D E.

Problem 13 — Draw any two lines A B and C D, and take any point F between them. Using F as a vertex, draw any triangle F-2-1. Take point 4 anywhere on C D, and draw 4-E and 4-3 parallel to 2-F and 2-1 respectively. Draw 3-E parallel to 1-F. Draw the line through E and F.

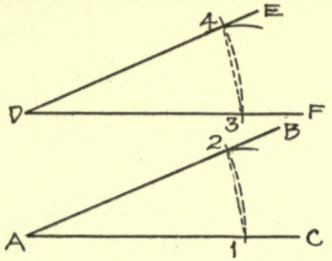
Problem 14 — Draw any two lines A B and C D. Draw another line E F whose length is greater than A B plus C D, and on it take 1-2 equal to A B and 2-3 equal to C D. Bisect 1-3, using the method of Problem 1. Taking 4 as a center, describe the semi-circumference. At 2 erect a perpendicular to E F. 2-5 will be the mean proportional between 1-2 and 2-3. (The mean proportional between two quantities is equal to the square root of their product.)

Problem 15 — Take any line A B. At B erect a perpendicular, using method of Problem 9. Using B as a center, draw arc A-1. Using A and 1 as centers, draw arcs B-2 and B-3-2 respectively, thus determining the remaining corner of the square.



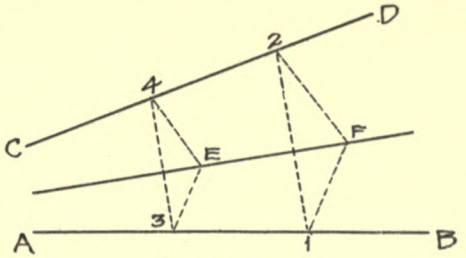
PROBLEM 11

THROUGH A POINT C TO DRAW A LINE PARALLEL TO AB.



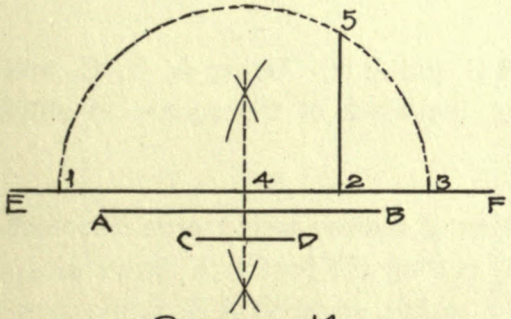
PROBLEM 12

TO CONSTRUCT AN ANGLE EQUAL TO A GIVEN ANGLE ABC.



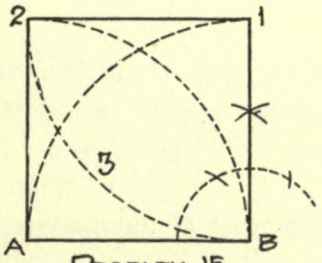
PROBLEM 13

THROUGH A GIVEN POINT F TO DRAW A LINE WHICH WOULD MEET INTERSECTION OF AB AND CD. PRODUCED.



PROBLEM 14.

TO FIND THE MEAN PROPORTIONAL BETWEEN AB AND CD.



PROBLEM 15

ON A GIVEN LINE AB TO CONSTRUCT A SQUARE

GEOMETRICAL PROBLEMS

DRAWN BY

DATE

PLATE NO. 5

INSTRUCTIONS.

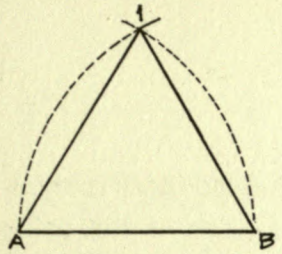
Problem 16 — Take any line A B. With A and B as centers, and a radius equal to A B, swing arcs intersecting at 1. Draw A-1 and B-1.

Problem 17 — Draw any three lines A B, C D, and E F. Taking A as a center, and a radius equal to E F, swing arc G H. Taking B as a center, and a radius equal to C D, describe arc L M. Complete the triangle.

Problem 18 — Draw any line A B. Using A and B as centers, and a radius equal to A B, swing arcs intersecting at O. Using O as a center, and the same radius, draw the circle. A-5, 5-4, 4-3, 3-2, and 2-B are each equal to the radius of the circle.

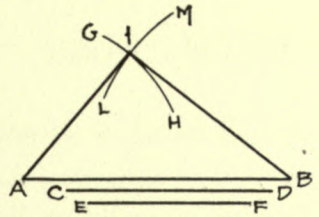
Problem 19 — Draw a square, as A B C D, and draw the diagonals A C and B D. Using A, B, C, and D as centers, describe arcs passing through 1. Connect points where the arcs cut the sides of the square to obtain the octagon.

Problem 20 — Draw a line A B. Using A and B as centers, and A B as a radius, swing arcs intersecting at 2 and 9. Draw M N. Using 9 as a center, describe an arc through A and B, cutting the first arcs drawn at 3 and 5. Draw 3-4-6 and 5-4-7. Draw A-7 and B-6. Taking 7 and 6 as centers, and a radius equal to A B, swing arcs intersecting at 8. Complete the pentagon.



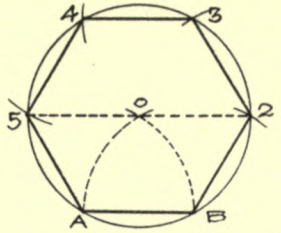
PROBLEM 16

ON A GIVEN LINE TO CONSTRUCT AN EQUILATERAL TRIANGLE.



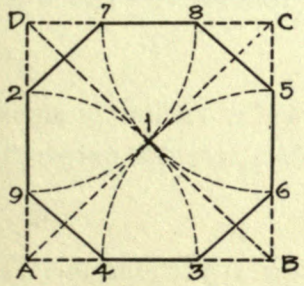
PROBLEM 17.

GIVEN THREE SIDES OF A TRIANGLE TO CONSTRUCT THE FIGURE.



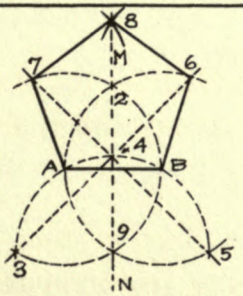
PROBLEM 18

ON A LINE AB TO CONSTRUCT A REGULAR HEXAGON.



PROBLEM 19

WITHIN A SQUARE TO CONSTRUCT AN OCTAGON



PROBLEM 20

ON A GIVEN LINE AB TO CONSTRUCT A PENTAGON

GEOMETRICAL PROBLEMS

DRAWN BY

DATE

PLATE NO. 6.

INSTRUCTIONS.

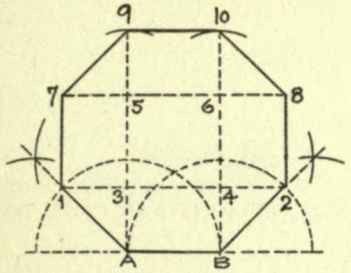
Problem 21 — Draw any line A B, and at A and B erect perpendiculars, using method of Problem 9. Bisect the right angles formed by the perpendiculars and A B produced. A-1 and B-2 will be sides of the octagon. Draw 1-2 and take 3-5 and 4-6 equal to A B. Take 5-9 and 6-10 equal to A-3 or B-4. Draw a line through 5 and 6 and take 5-7 and 6-8 equal to 1-3 or 2-4.

Problem 22 — Draw any triangle. Bisect any two angles, using method of Problem 3. The intersection of the bisectors is the center of the inscribed circle.

Problem 23 — Draw any triangle, and bisect any two sides, using method of Problem 1. The intersection of the bisectors is the center of the circumscribed circle.

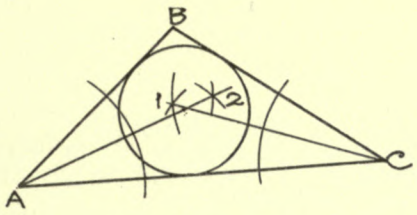
Problem 24 — Draw a circle, and take any point A on the circumference. Draw a radius produced through A, as O P, and on it from A lay off equal distances A-2 and A-3. Using 2 and 3 as centers, erect a perpendicular at A. This will be the required tangent.

Problem 25 — Draw any arc of a circle. Take any point A on the arc and draw any chord A-1. Bisect A-1 and draw the bisector. Taking A as a center, swing an arc through 3 and lay off 3-4 equal to 3-5. Draw the tangent through 4 from A.



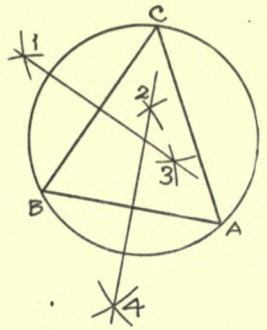
PROBLEM 21

ON A GIVEN LINE AB TO CONSTRUCT AN OCTAGON.



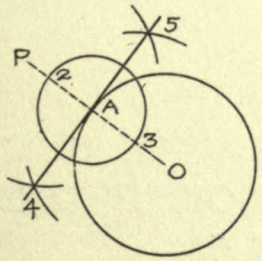
PROBLEM 22

WITHIN A TRIANGLE TO INSCRIBE A CIRCLE



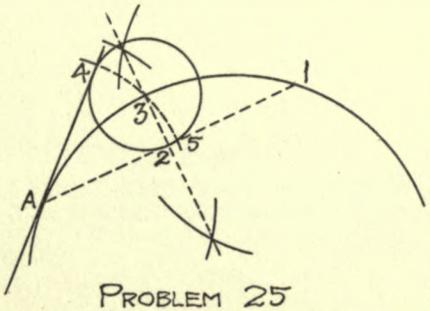
PROBLEM 23

TO CIRCUMSCRIBE A CIRCLE ABOUT A TRIANGLE.



PROBLEM 24

TO DRAW A TANGENT TO A CIRCLE AT A GIVEN POINT A.



PROBLEM 25

TO DRAW A TANGENT TO A CIRCLE AT A GIVEN POINT A WHEN CENTER IS INACCESSIBLE

GEOMETRICAL PROBLEMS

DRAWN BY

DATE

PLATE NO. 7

PROBLEM 26

CONSTRUCT AN ANGLE OF 15 DEGREES

PROBLEM 27

GIVEN AN ANGLE AND THE INCLUDED SIDES OF A TRIANGLE TO CONSTRUCT THE TRIANGLE.

PROBLEM 28

GIVEN TWO ANGLES AND ONE SIDE OF A TRIANGLE TO CONSTRUCT THE TRIANGLE

PROBLEM 29

GIVEN ONE LEG AND THE HYPOTENUSE OF A RIGHT ANGLE TRIANGLE TO CONSTRUCT THE TRIANGLE

PROBLEM 30

GIVEN THE ADJACENT SIDES OF A RECTANGLE TO CONSTRUCT THE FIGURE.

GEOMETRICAL PROBLEMS

DRAWN BY .

DATE

PLATE NO. 8

PROBLEM 31

TO CONSTRUCT A SQUARE HAVING GIVEN THE DIAGONAL

PROBLEM 32

TO CONSTRUCT A RHOMBUS HAVING GIVEN A SIDE AND THE ACUTE ANGLE.

PROBLEM 33

TO CONSTRUCT A TRAPEZOID HAVING GIVEN THE FOUR SIDES.

PROBLEM 34

ASSUME ANY THREE POINTS. DRAW A CIRCLE WHICH SHALL PASS THROUGH THESE POINTS

PROBLEM 35

DRAW AN OCTAGON USING THE 45° TRIANGLE AND INSCRIBE A CIRCLE IN IT AND CIRCUMSCRIBE A CIRCLE ABOUT IT.

GEOMETRICAL PROBLEMS

DRAWN BY

DATE

PLATE NO. 9

CONIC SECTION CURVES.

There are several conic section curves used to a considerable extent by draftsmen. Some of the methods used for the construction of these curves are illustrated by the figures on Plates 10 and 11. There are many methods in use for the construction of these curves, but the ones given are among the most simple of those generally employed.

If a regular cone was cut by a plane parallel to the base, the outline of the cross section would be a circle. If the cutting plane was not parallel to the base and did not cut the base, the outline of the section would be an ellipse. If the cutting plane did cut the base, the outline of the curve of the section would be a parabola. If two planes were passed through a cone parallel to the altitude, and at an equal distance each side of it, the curves of the hyperbola would be obtained.

An ellipse is a curve which is the locus of a point moving in a plane so that the sum of its distances from two fixed points in the plane is constant.

A parabola is a curve which is the locus of a point moving in a plane so that its distance from a fixed point in the plane is always equal to its distance from a fixed line in the plane.

An hyperbola is a curve which is the locus of a point moving in a plane so that the difference of its distances from two fixed points in the plane is constant.

The drawing of these curves is required so that the student may acquire proficiency in the use of the irregular curve. The intention is not to emphasize the mathematical importance or connection with the cone.

Instructions Draw the major axes AB 10" long and the minor axes CD 7" long. The ellipse of Fig. 1 is drawn by the method of trammels. Take a strip of paper and on its edge lay off M = ½ major axis or 5" and N = ½ minor axis or 3½". Keep the point 1 always on the minor axis and the point 2 always on the major. Spot the points 3 obtained by revolving the trammel and connect them using the irregular curve. In Fig. 2 take OH and OF equal to difference between major and minor axes (3) and take OE and OG equal to three fourths of OH or OF. Using E, F, G and H as centers draw the ellipse.

5" 9" 5"

Place no dimensions on the finished sheet.

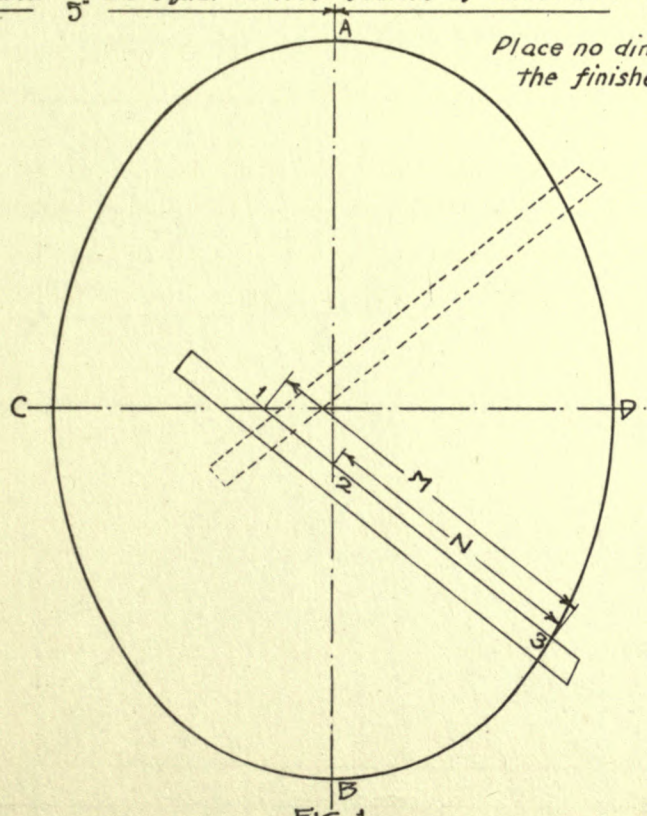


FIG. 1

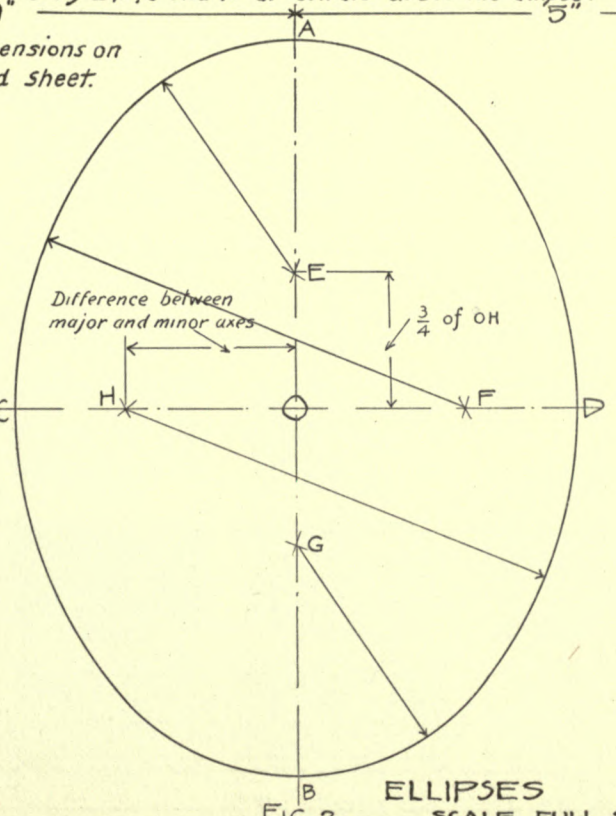


FIG 2

ELLIPSES

SCALE FULL SIZE

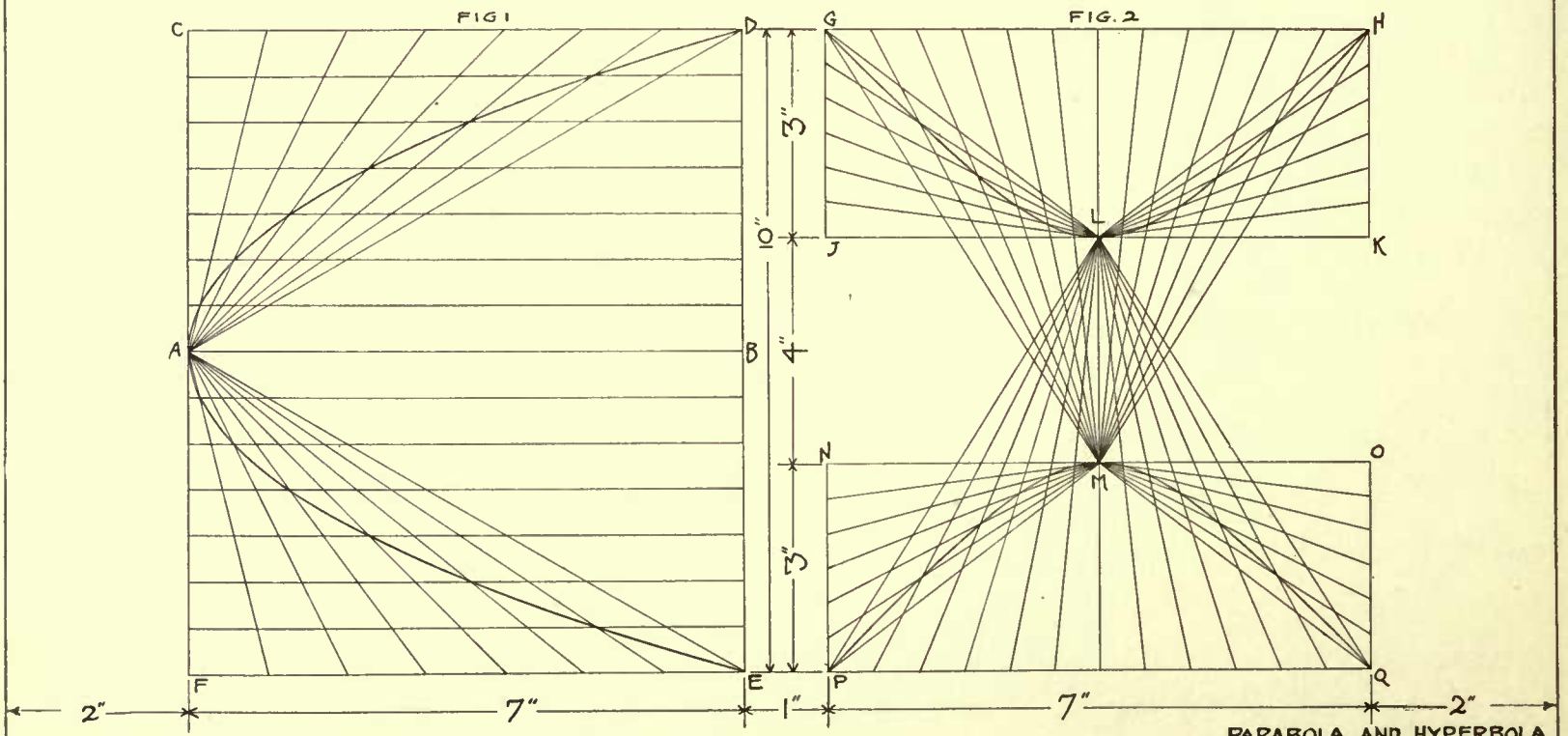
DRAWN BY

DATE

PLATE NO 10

Instructions Draw rectangles of dimensions as given. Using the dividers divide the sides of the rectangles as shown. Note that in Fig. 1 CD contains half as many divisions as DE. and that in Fig. 2 GJ contains half as many divisions as GH. Draw the lines and connect points shown using the irregular curve. The curve of the first figure is that of the parabola; that of the second that of the hyperbola. AB is called the abscissa and DE the double ordinate. ML is called the axis and PQ the double ordinate.

Place no dimensions on the finished sheet.



PARABOLA AND HYPERBOLA
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO 11

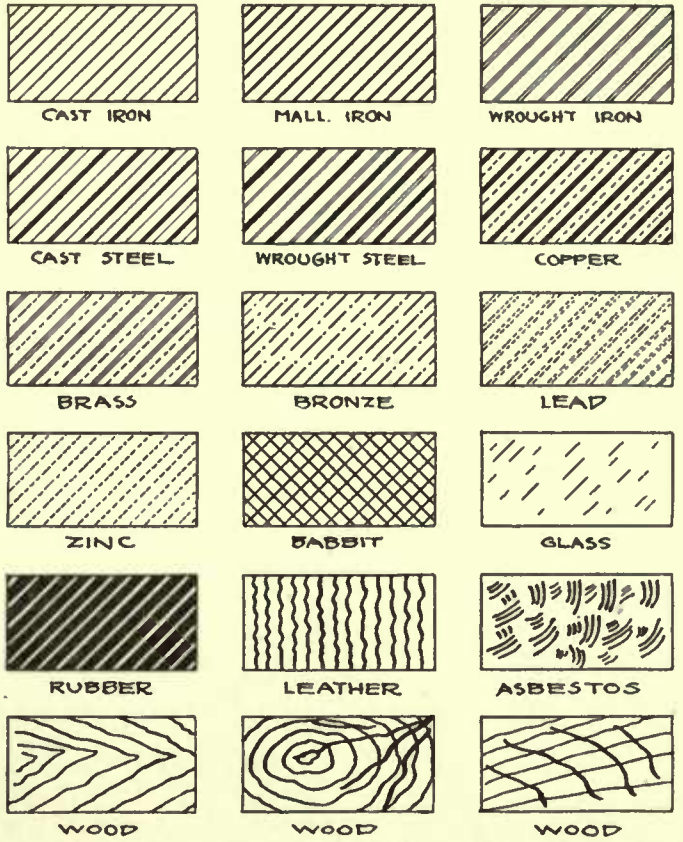
DIMENSION LINE–ARROW HEAD

FULL LINE

SHADE LINE

DOTTED LINE

CENTER LINE



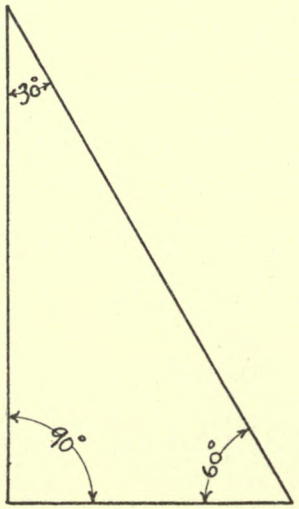
STANDARD LINES AND CROSS SECTIONS

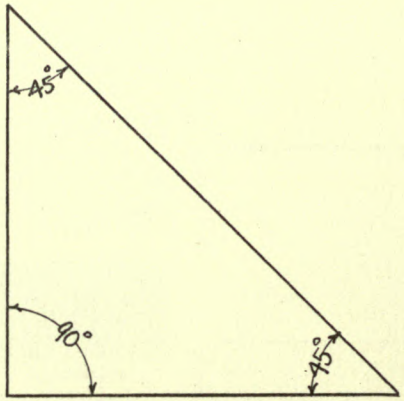
DRAWN BY

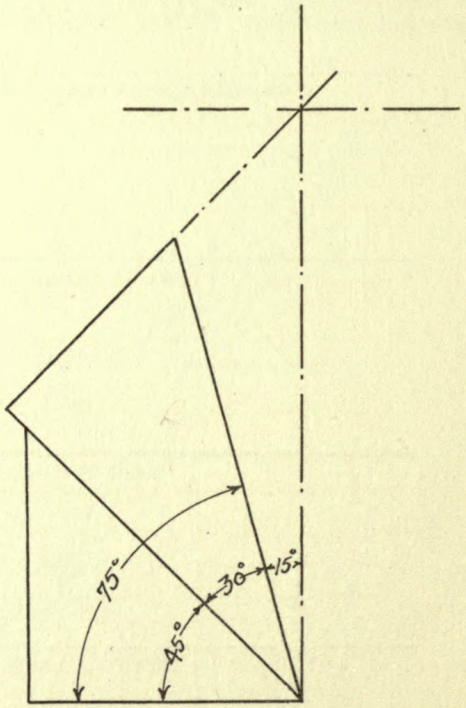
DATE

PLATE NO 12

Instructions Draw to any convenient scale but arrange neatly. This plate is to be inked. Cross-section lines are drawn 45°







Instructions

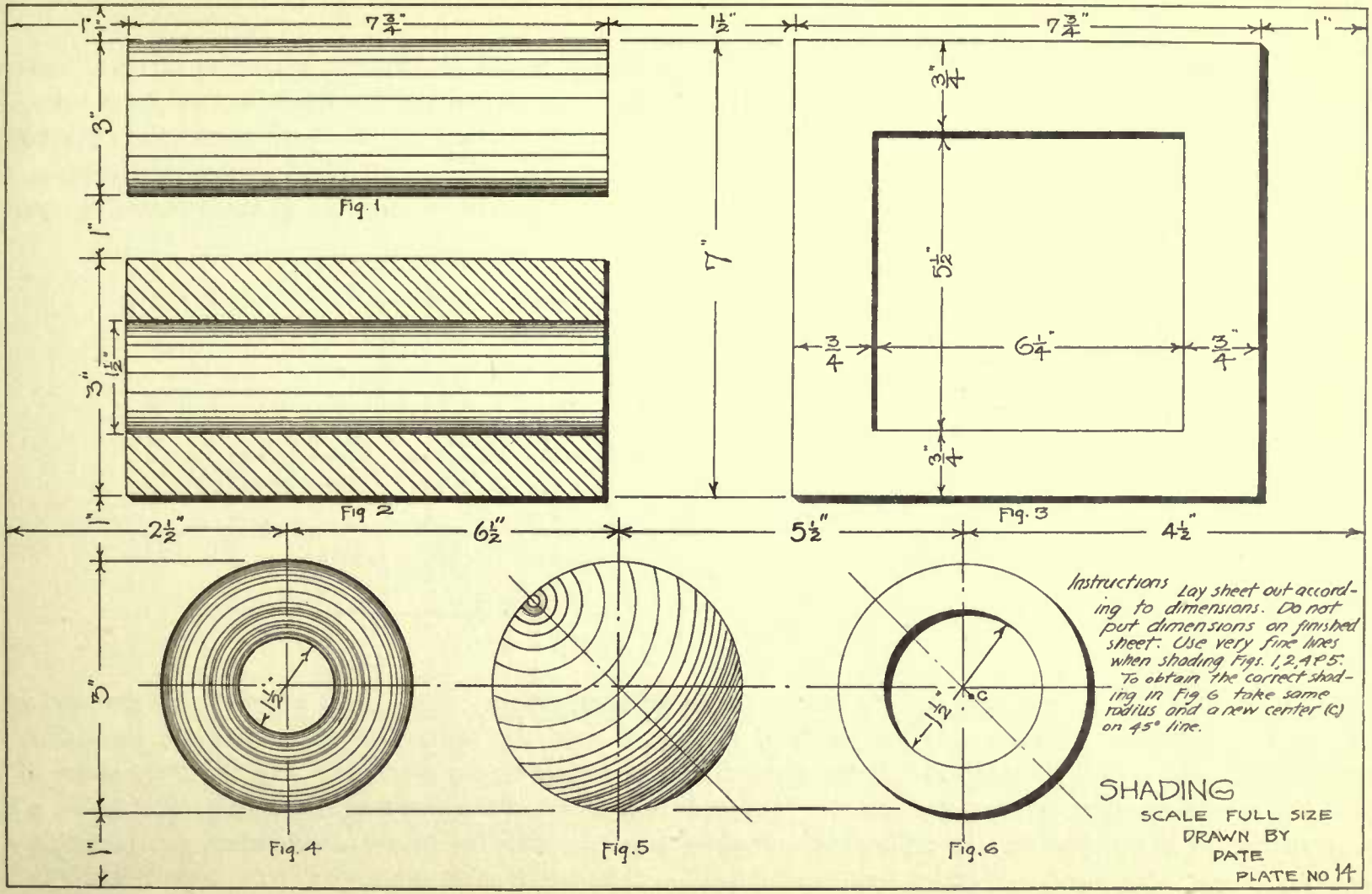
Lay out triangles so that general appearance of finished sheet will be like this sheet.

USE OF TRIANGLES

DRAWN BY

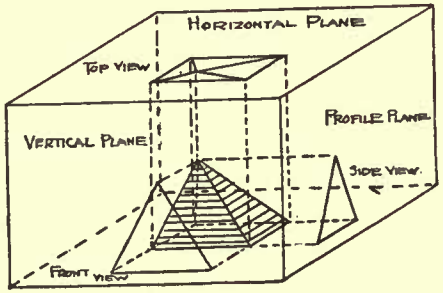
DATE

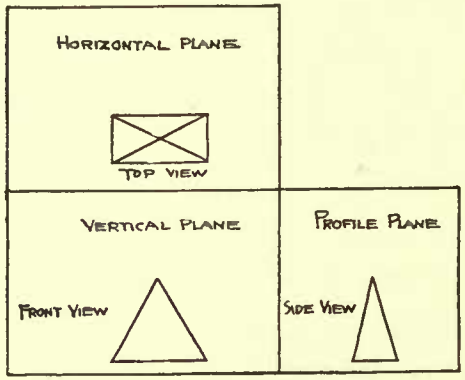
PLATE NO. 13


1"
7¾"
1½"
7¾"
1"
3"
1"
Fig. 1
3"
1½"
1"
Fig 2
17"
3¼"
5½"
¾
6¼"
¾
3¼"
Fig. 3
2½"
6½"
5½"
4½"
3"
1½"
Fig. 4
Fig. 5
C
1½"
Fig. 6
Instructions Lay sheet out according to dimensions. Do not put dimensions on finished sheet. Use very fine lines when shading Figs. 1, 2, 4 & 5. To obtain the correct shading in Fig 6 take same radius and a new center (C) on 45° line.
SHADING
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO 14

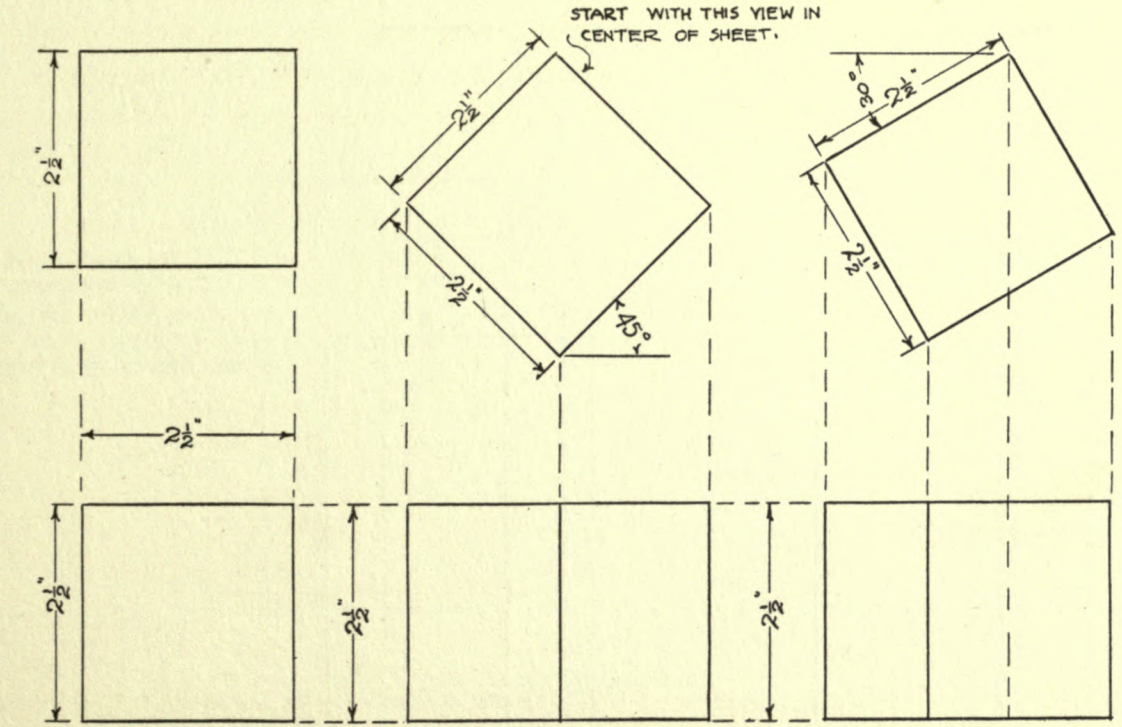
ORTHOGRAPHIC PROJECTION.

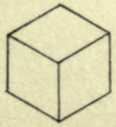
Orthographic projection is a process in drawing by the use of which we find the projection of lines, surfaces, or solids upon three planes, namely, the horizontal, the vertical, and the profile. To illustrate how these planes are related to one another, may we suppose that an object such as a rectangular pyramid has been placed upon the bottom of a rectangular box. The top of the box represents the horizontal plane, the rear or front face the vertical plane, and the right hand face the profile plane. Projections of the object may be obtained upon all of these planes by drawing





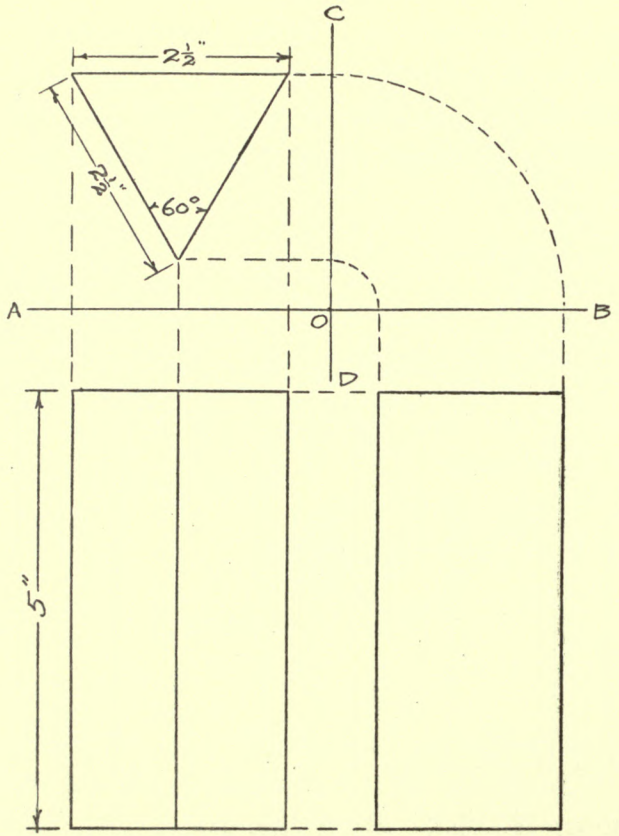
perpendiculars from the several points of the object to the different planes. The points at which the perpendiculars pierce the planes are the projections of the points of the object upon the planes. If the points are connected, the projection of the faces will be obtained. If the three planes of projection are made into one, the three views of the object will appear as we must represent them. Take particular notice of the fact that lines not parallel to the planes appear shorter in the projection. In orthographic drawing objects appear as they are projected, not necessarily as they actually are. Dimension all plates from now on unless otherwise specified.

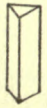




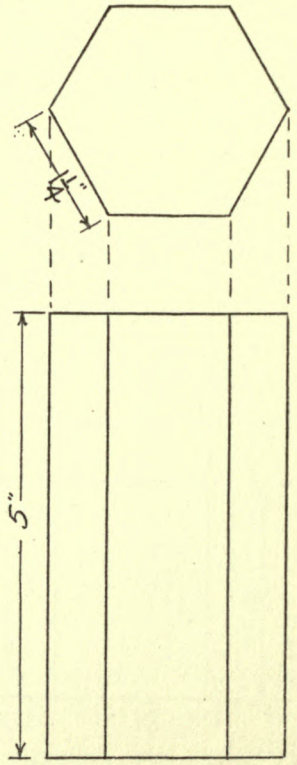
Instructions This sheet represents the top and front views of a cube shown in various positions. The final appearance of the finished sheet should be like above

CUBE
SCALE FULL SIZE
DRAWN BY
DATE.
PLATE NO 15



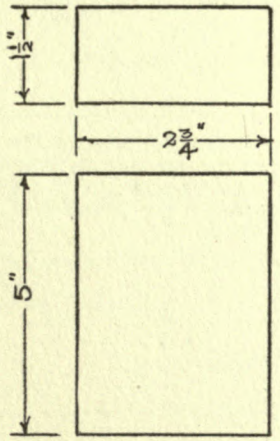


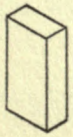
The top, front and side views of a triangular prism are shown above. AB and CD are drawn in any convenient place. O is used as a center.



The front and top views of a hexagonal prism are here shown. The side view must be drawn using the method of the preceding problem.

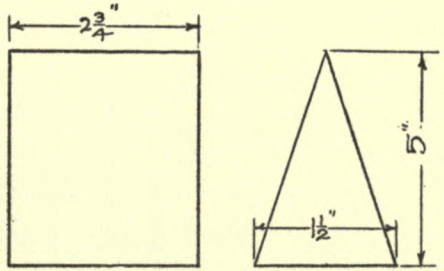
TRIANGULAR AND HEXAGONAL PRISMS
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO 16





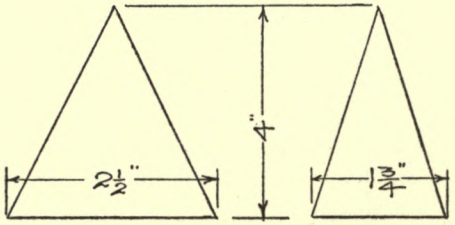
The front and top views of a rectangular prism are here shown. Construct the side view.

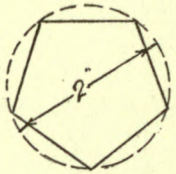
The front and side views of a triangular prism are here given. Construct the top view

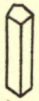


RECTANGULAR AND TRIANGULAR PRISMS
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO. 17

The front and side views of a rectangular pyramid are here shown. Construct the top view.







Draw the top view of the pentagonal prism shown above by drawing a 2" circle, dividing the circumference into five equal parts and connecting the points obtained. Construct the front and side views. Make the altitude 4"

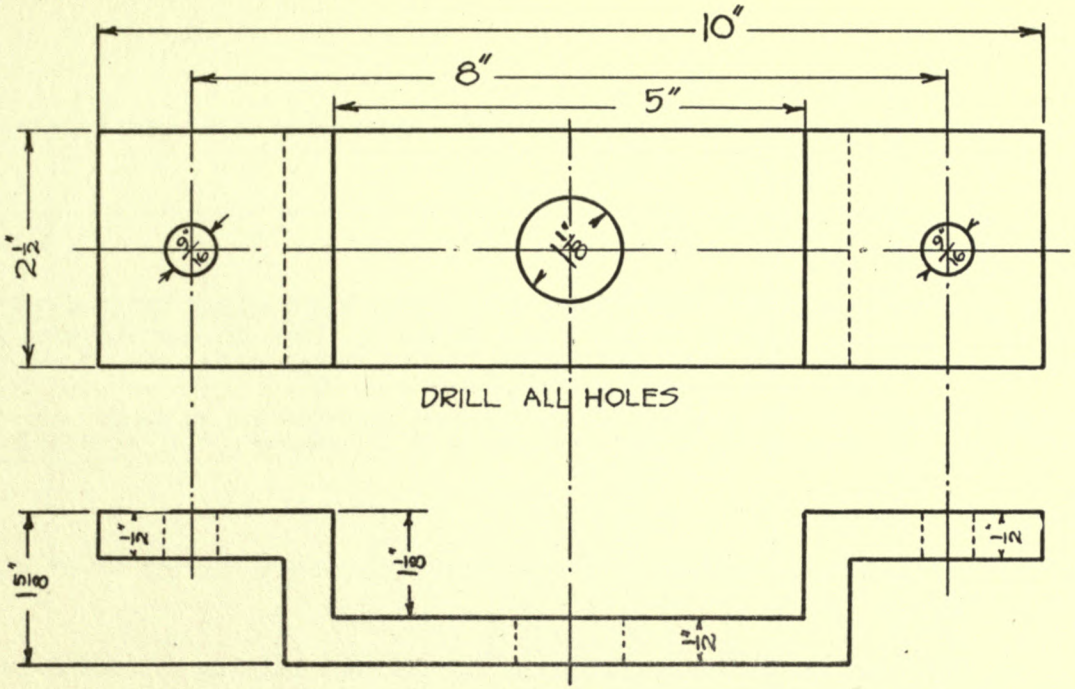
RECTANGULAR PYRAMID & PENTAGONAL PRISM

SCALE FULL SIZE.

DRAWN BY

DATE

PLATE NO. 18



INSTRUCTIONS

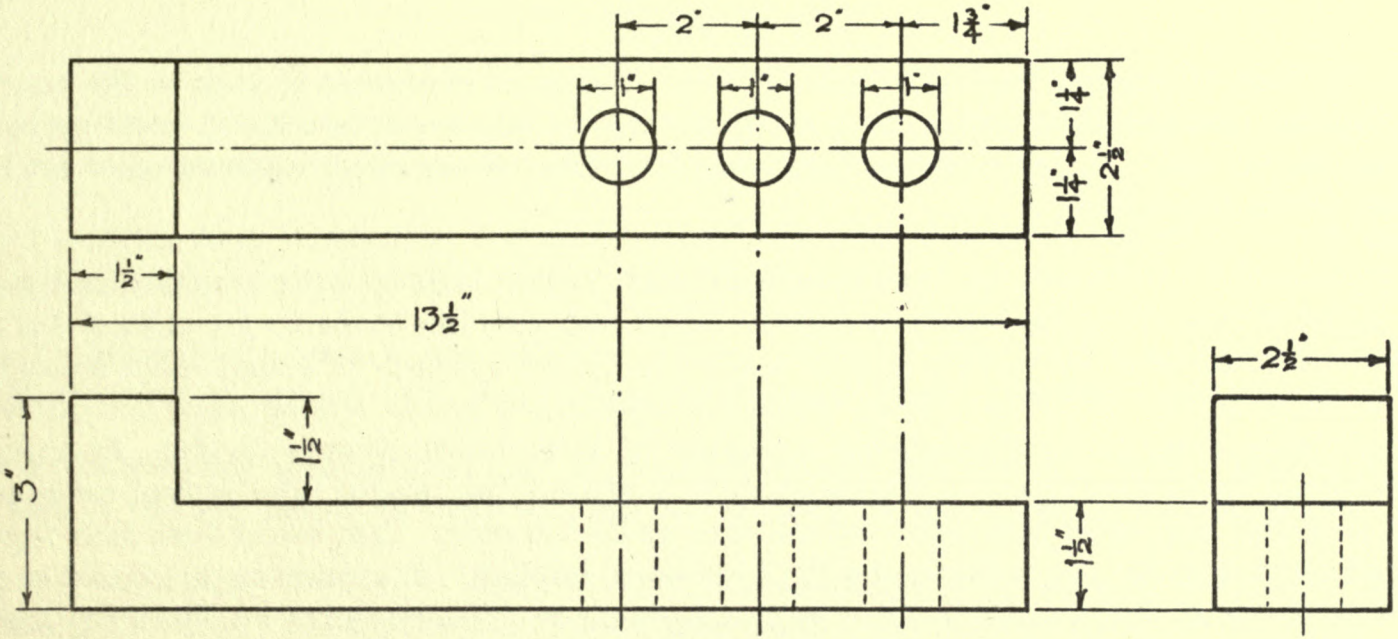
DRAW ON WHITE PAPER AND INK. TRY TO GET A NOTICEABLE DISTINCTION BETWEEN THE DIFFERENT KINDS OF LINES FULL LINES ARE TO BE HEAVIER THAN DOTTED AND DIMENSION LINES

MACHINE DETAIL
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO. 19

MAKE A DRAWING IN ORTHOGRAPHIC PROJECTION OF A HEXAGONAL PRISM HAVING AN ALTITUDE OF 3", THE DIAMETER OF THE INSCRIBED CIRCLE OF THE BASE BEING $1\frac{7}{8}$". ONE OF THE NARROW FACES IS TO REST ON THE HORIZONTAL PLANE, THE HEXAGONAL BASES BEING PARALLEL TO THE PROFILE PLANE.

DRAW A SQUARE PYRAMID IN ORTHOGRAPHIC PROJECTION RESTING ON ITS BASE AND MAKING AN ANGLE OF 15° WITH THE VERTICAL PLANE. THE BASE IS 2" SQUARE, THE ALTITUDE $3\frac{1}{8}$"

HEXAGONAL PRISM AND SQUARE PYRAMID
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO 20



FINISH OVER ALL WROUGHT IRON

INSTRUCTIONS

DRAW ON WHITE PAPER AND INK

BLOCK FOR REPLACING LOCOMOTIVE TIRES

SCALE FULL SIZE

DRAWN BY

DATE

PLATE NO. 21

THE USE OF THE SCALE.

(READ THIS CAREFULLY.)

Up to this point all drawings have been made full size. That is, all dimensions as given on the paper are represented by distances possessing true value. It is, of course, easy for any one to see that it would not be possible to make all drawings full size. The drawing of a house or a large piece of machinery obviously could not be made of the same size as the object itself.

The scale, used by draftsmen, has been so arranged that drawings may be made bearing almost every proportion to the object without doing any actual computing. This is not often true of the six inches equal one foot. That scale is rarely given, but any one who can't divide a quantity by two and get the correct result should not adopt a drafting or technical calling. But if one wished to make a drawing one quarter size he would first divide twelve by four, the result being three, and on the scale find a distance of three inches properly divided. An examination of this three-inch scale would show how it is possible to make a drawing one quarter size without computation. The three inches is divided into twelve equal parts just the same as the full scale. Each one of these parts represents one inch in just the same way that one twelfth of the full scale equals one inch. The inches are subdivided on the smaller scales in the same way as on the full size if it is practicable to do so. Measure from the three-inch scale as from the full scale and without computation.

Study the one eighth or one and one half inches equal one foot scale, and in addition all of the others down to the one eighth and one sixteenth inches equal one foot. Don't forget, of course, that all dimensions must be numbered full size. It hardly seems necessary to give the reason.

PLATE 22.

Divide the sheet inside the border into six equal parts in the same way as previously done for the Geometrical Problems. In the six spaces thus formed draw according to following directions:—

Space 1—Make three views of a rectangular pyramid, the base of which is two inches by two and one half inches, the altitude being four and one half inches. Call this Figure 1.

Space 2—Make three views of the object of Figure 1 revolved about an axis perpendicular to the vertical plane, the base making an angle of thirty degrees with the horizontal plane. Call this Figure 2.

Space 3—Make three views of the object of Figure 2 revolved about an axis perpendicular to the horizontal plane, the edge of its base making an angle of fifteen degrees with the vertical plane. Call this Figure 3.

Space 4—Make three views of the object of Figure 1 revolved about an axis perpendicular to the profile plane, the base making an angle of ten degrees with the horizontal plane. Call this Figure 4.

Space 5—Make three views of the object of Figure 3 revolved about an axis perpendicular to the profile plane, the base making an angle of fifteen degrees with the horizontal plane. Call this Figure 5.

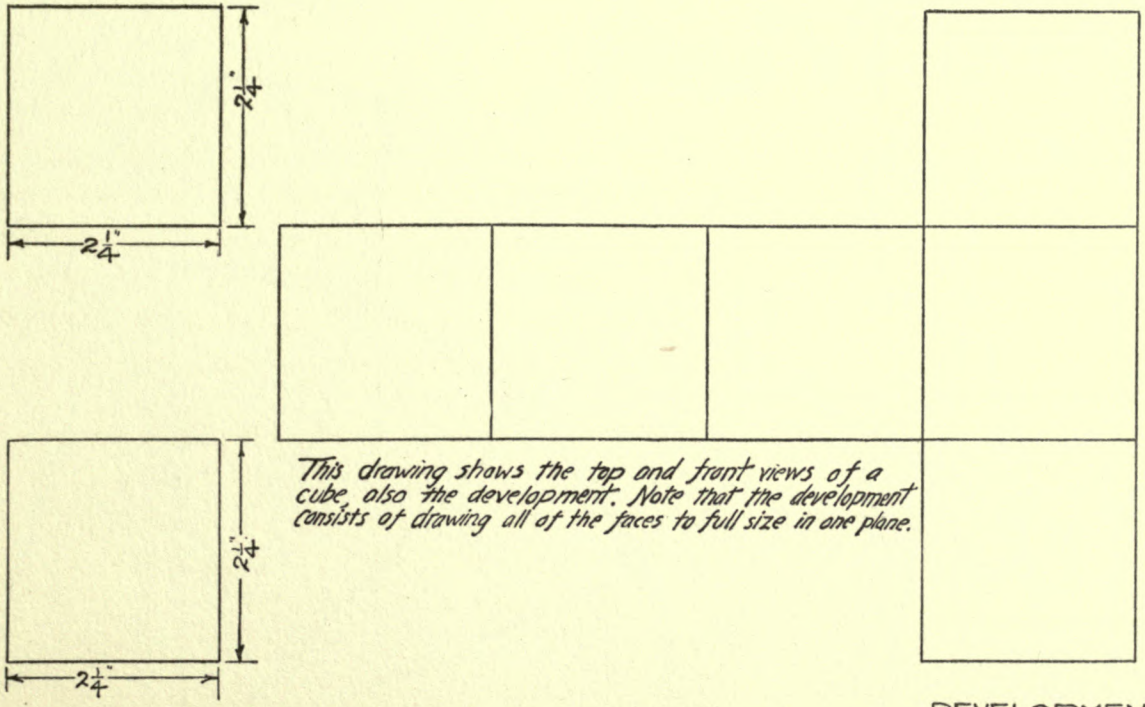
Space 6—This space is reserved for the title. Arrange it in the same way as for the geometrical plates. The title is Orthographic Projection. The scale is six inches equal one foot.

DEVELOPMENTS.

(READ CAREFULLY.)

The development of the surfaces of a solid requires that all of the faces of the solid shall be shown upon one plane, all of them being in their true size and all of them bearing the same relation to each other in the development as in the solid itself. Great care should be observed in the securing of the lines. If these are not obtained in their true length the development can not be correct. This is well illustrated in the case of the pyramid and the cone. It will be noticed here that the edge must be swung around into the vertical plane before the true length can be procured. A good check on the work is to cut out the development and fold it together. If the surfaces as developed do not enclose the solid whose surfaces it is supposed to represent, there is a mistake somewhere.

In actual practice many things are cut out from metal, folded together, and soldered and formed into useful things of one kind or another. All of this work is based upon and is a practical application of these development problems. When work of this sort is to be done allowance should always be made for a lap. Otherwise the surfaces could not be soldered together. It is suggested that all students develop some of the common receptacles familiar to them. A sheet of suggested objects is given at the end of this chapter.



This drawing shows the top and front views of a cube, also the development. Note that the development consists of drawing all of the faces to full size in one plane.

DEVELOPMENT OF A CUBE

SCALE FULL SIZE

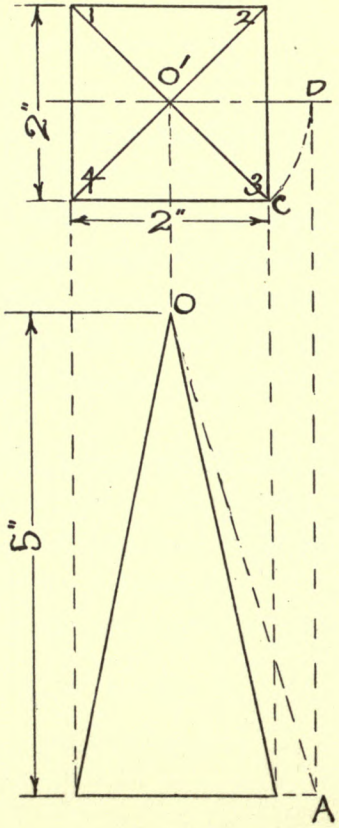
DRAWN BY

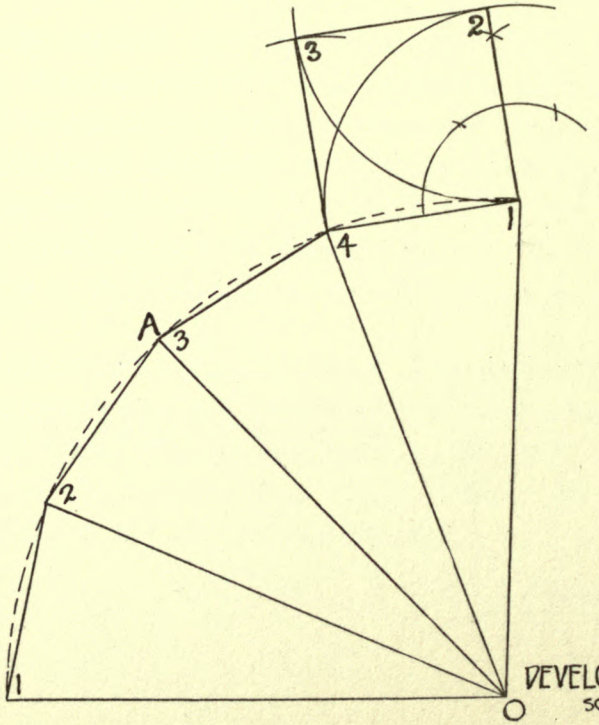
DATE

PLATE NO. 23

Instructions

Draw top and front views of pyramid as shown. To obtain true length of edge swing arc CD using O' as a center and O'C as a radius. Project from D to A. OA will be the radius to use in obtaining the development.





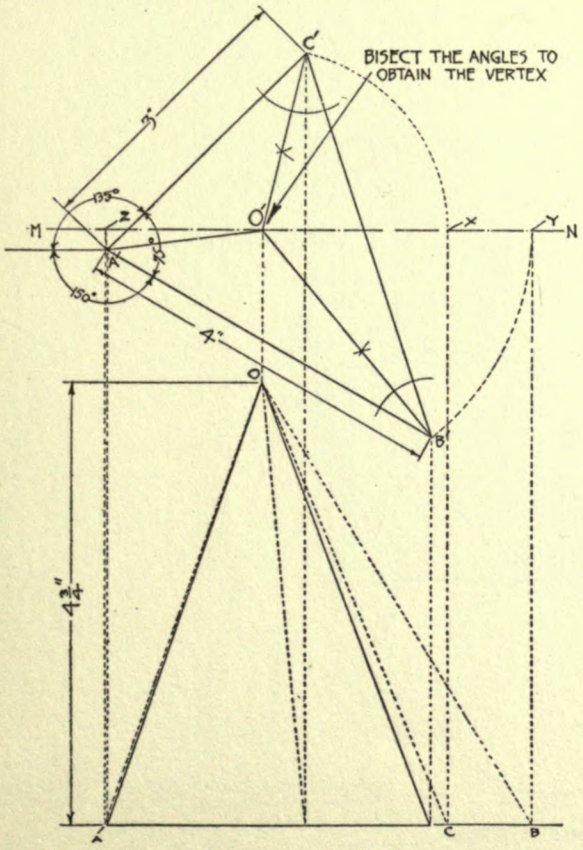
DEVELOPMENT OF A PYRAMID

SCALE FULL SIZE

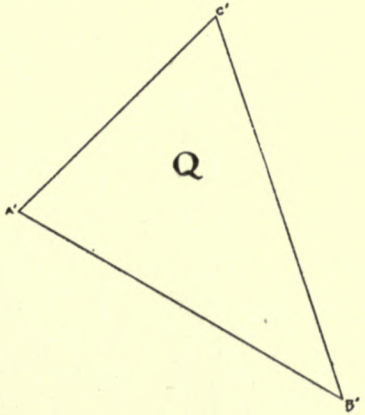
DRAWN BY

DATE

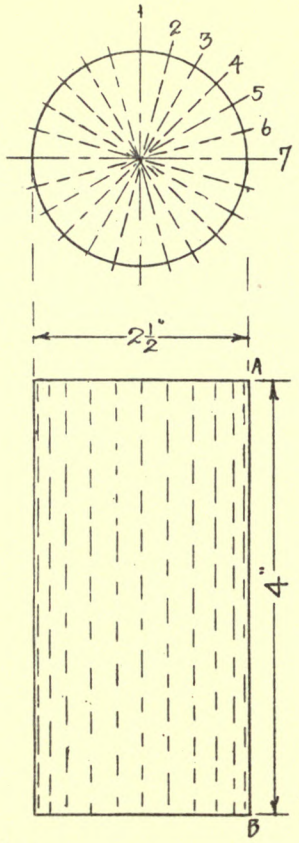
PLATE NO. 24

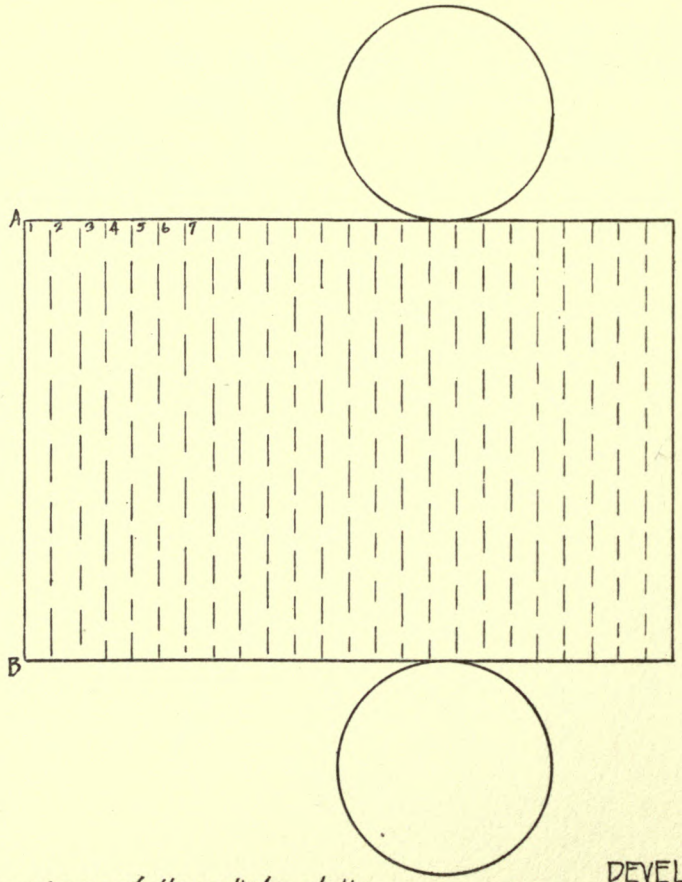


Instructions Draw the triangle A'B'C'. After bisecting the angles obtain the front view of the pyramid in the usual manner Using O' as a center describe arcs cutting MN at X, Y, and Z Project down to get A, B and C Draw OA, OB and OC Make the triangle Q equal to the base of the pyramid The lateral faces must be constructed in their true size upon the edges of Q This is left as an exercise for the student



DEVELOPMENT OF TRIANGULAR PYRAMID
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO. 25





Instructions

Draw the front and top views of the cylinder at the left of the sheet. Construct the development by drawing a rectangle whose altitude is the same as the altitude of the cylinder and whose length is the same as the length of the circumference of a base of the cylinder. Draw the circular bases.

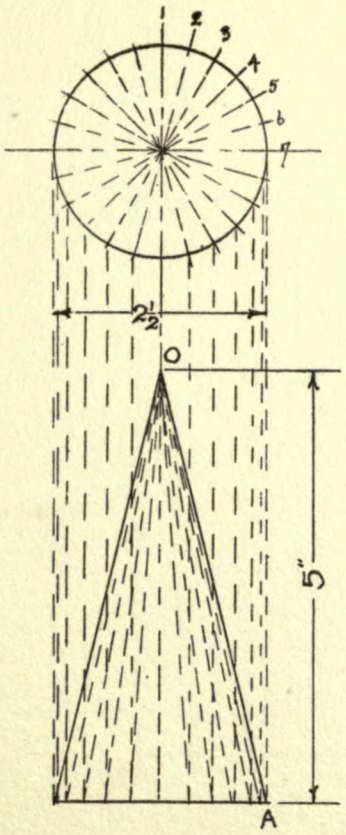
DEVELOPMENT OF A CYLINDER

SCALE FULL SIZE

DRAWN BY

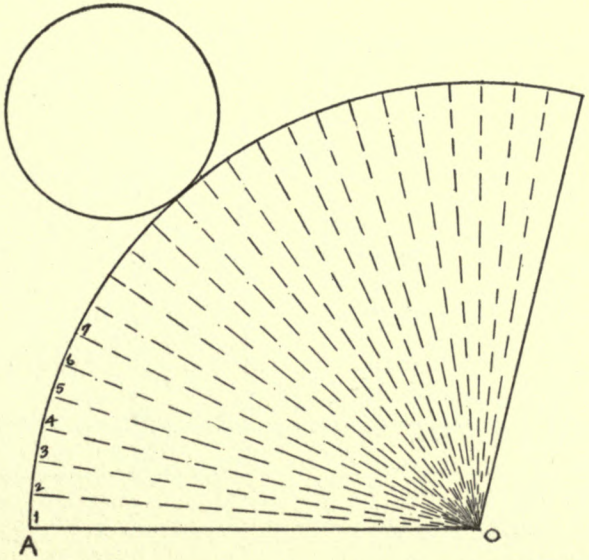
DATE

PLATE NO. 26



Instructions:

Draw the front and top views of the cone at the left of the sheet. Draw the development by swinging an arc using a radius OA. On this arc lay off 24 divisions each equal to one of the 24 divisions of the circumference of the base. Draw the circular base tangent to the arc at any convenient point.



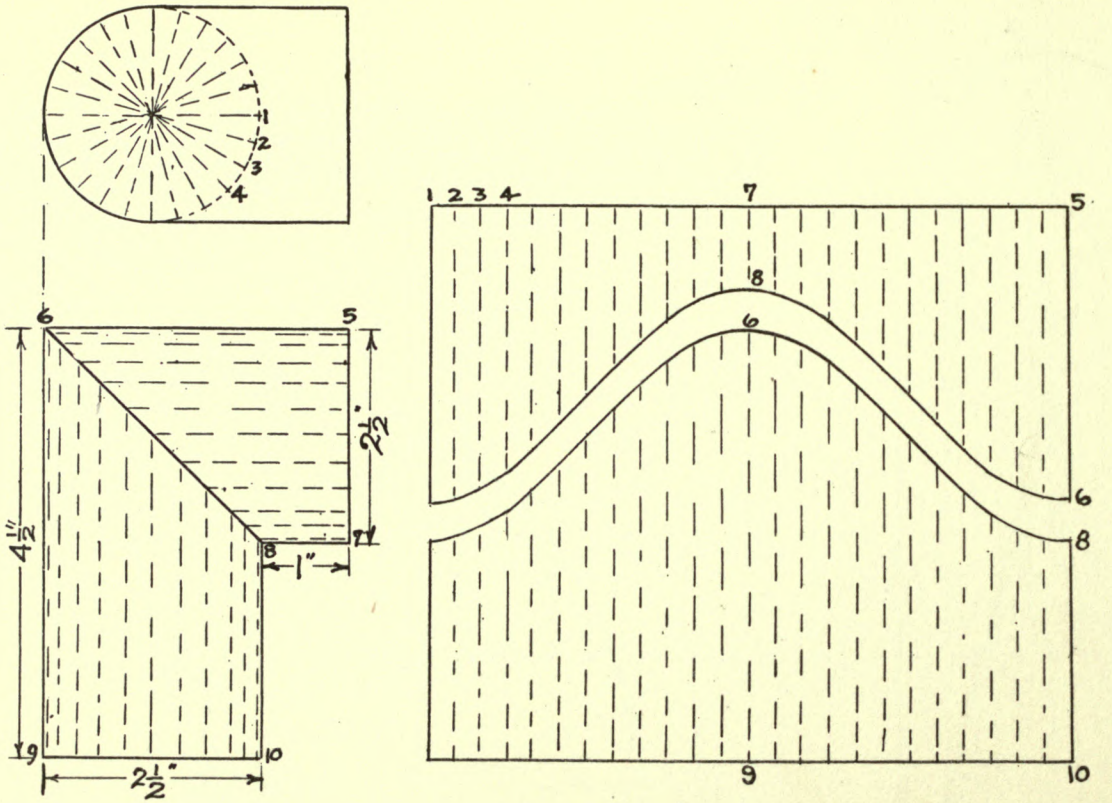
DEVELOPMENT OF A CONE.

SCALE FULL SIZE.

DRAWN BY

DATE.

PLATE NO. 27



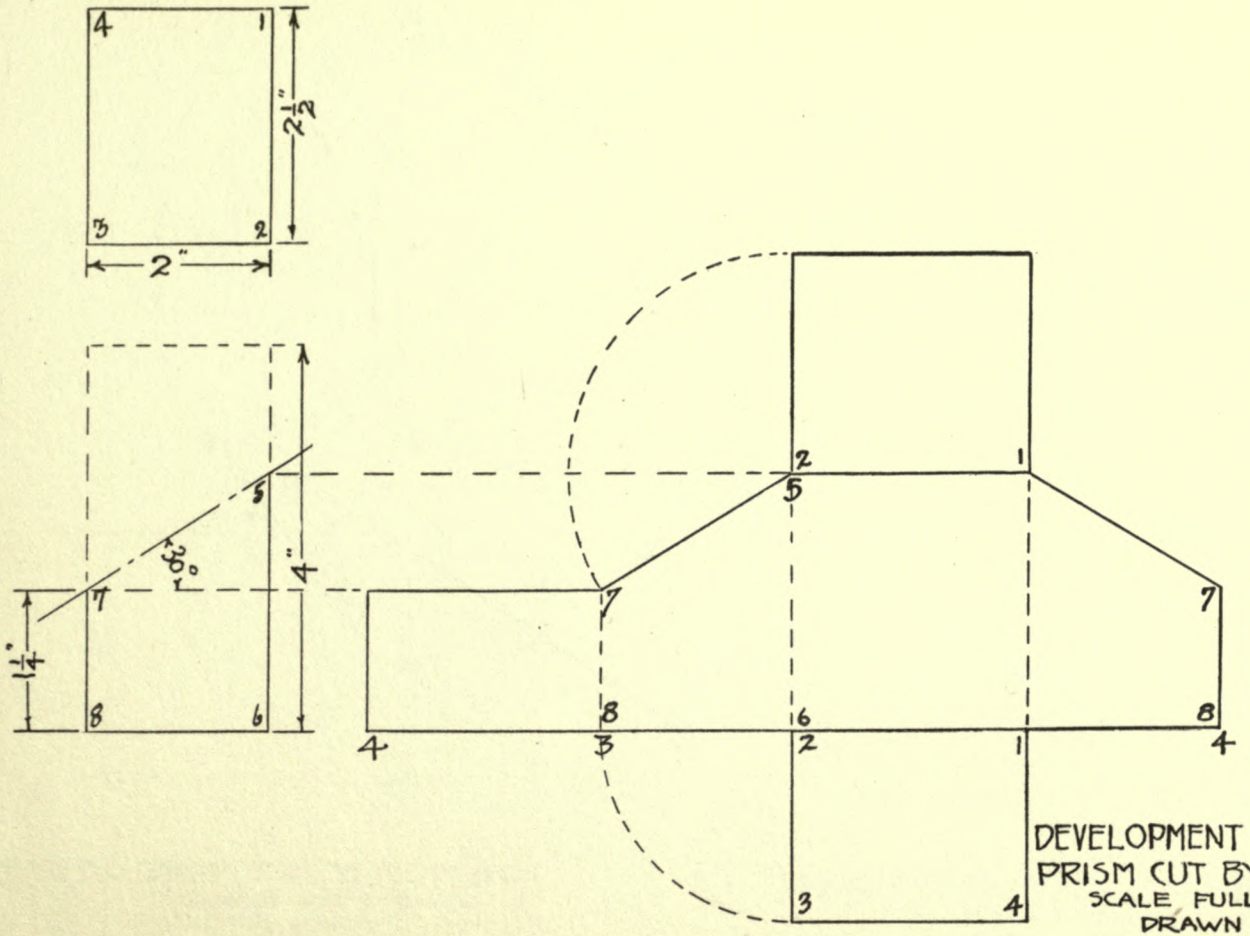
DEVELOPMENT OF AN ELBOW

SCALE FULL SIZE

DRAWN BY

DATE

PLATE NO. 28



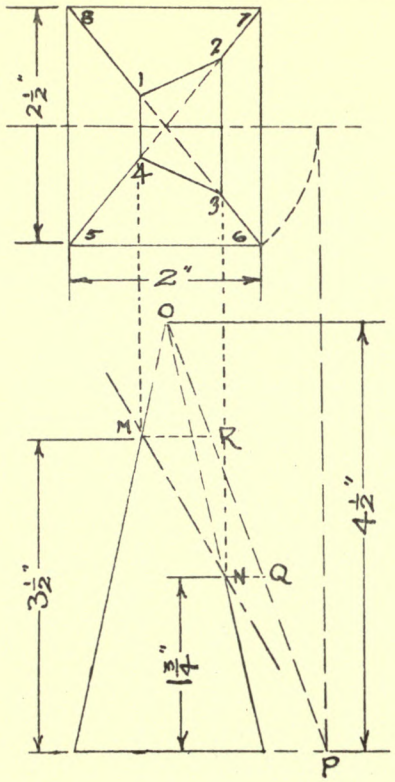
DEVELOPMENT OF A RECTANGULAR PRISM CUT BY A PLANE

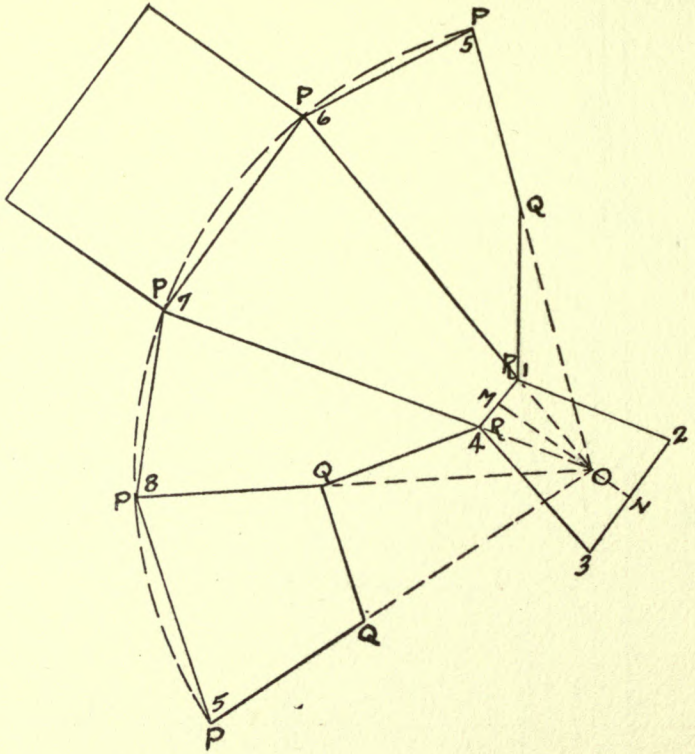
SCALE FULL SIZE

DRAWN BY

DATE

PLATE NO. 29





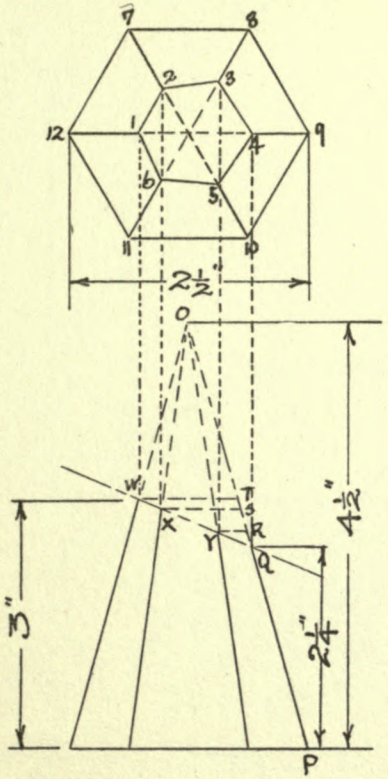
DEVELOPMENT OF RECT. PYRAMID CUT BY PLANE.

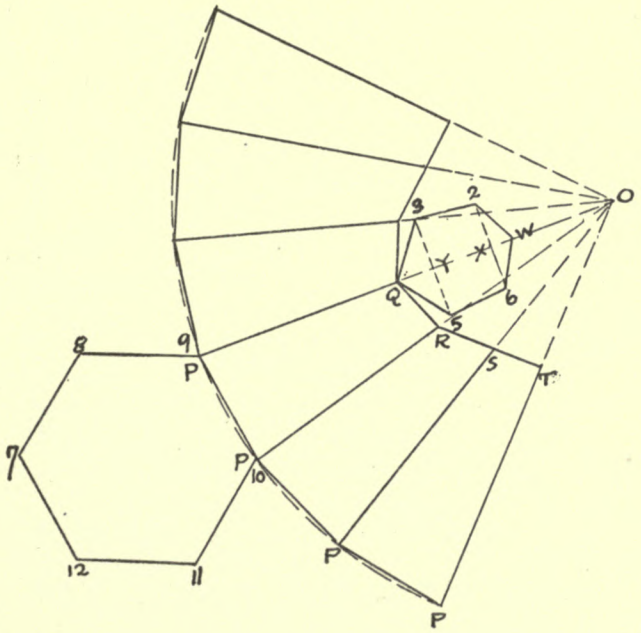
SCALE FULL SIZE

DRAWN BY

DATE

PLATE NO. 30





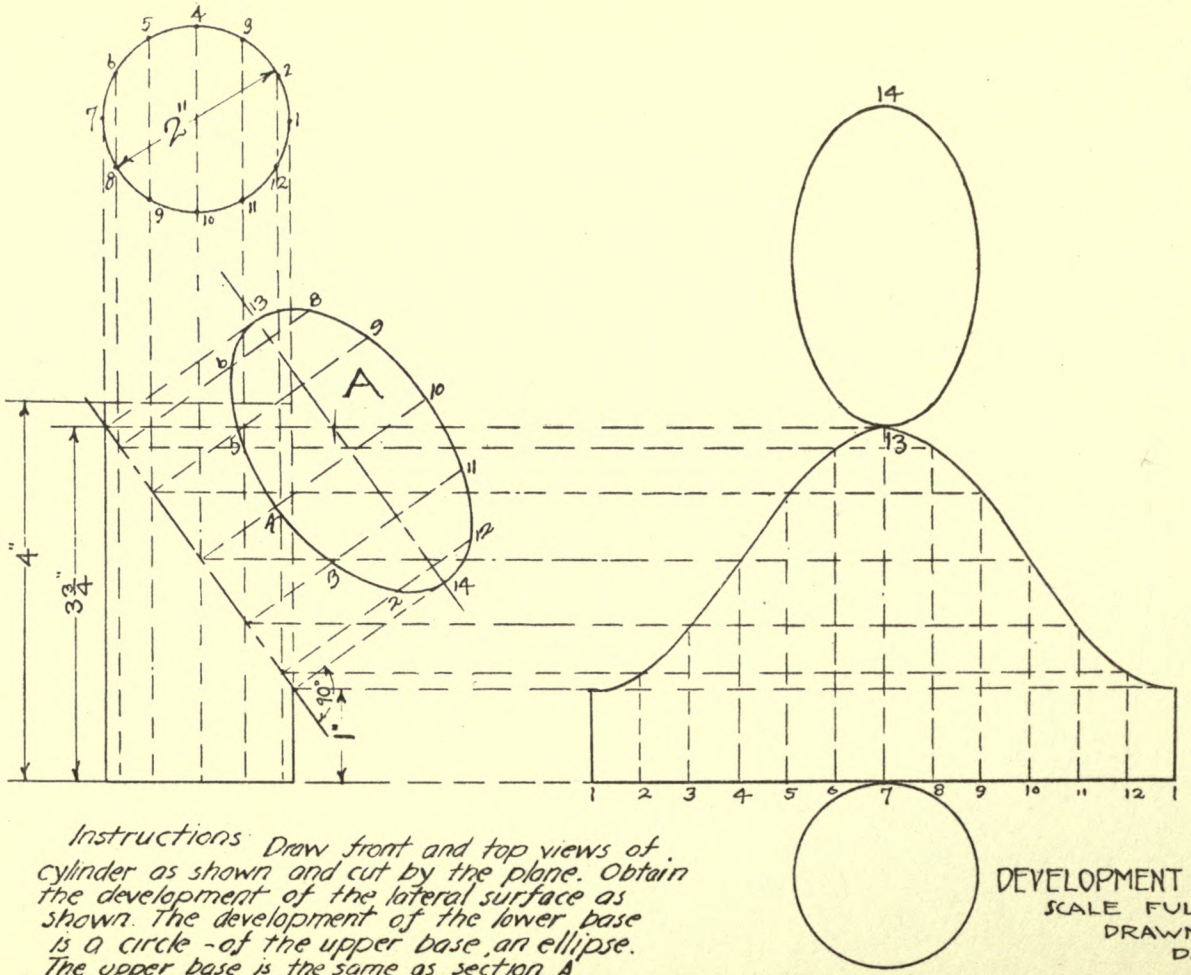
DEVELOPMENT OF HEXAGONAL PYRAMID CUT BY PLANE.

SCALE FULL SIZE.

DRAWN BY

DATE

PLATE NO 31



Instructions Draw front and top views of cylinder as shown and cut by the plane. Obtain the development of the lateral surface as shown. The development of the lower base is a circle - of the upper base, an ellipse. The upper base is the same as section A

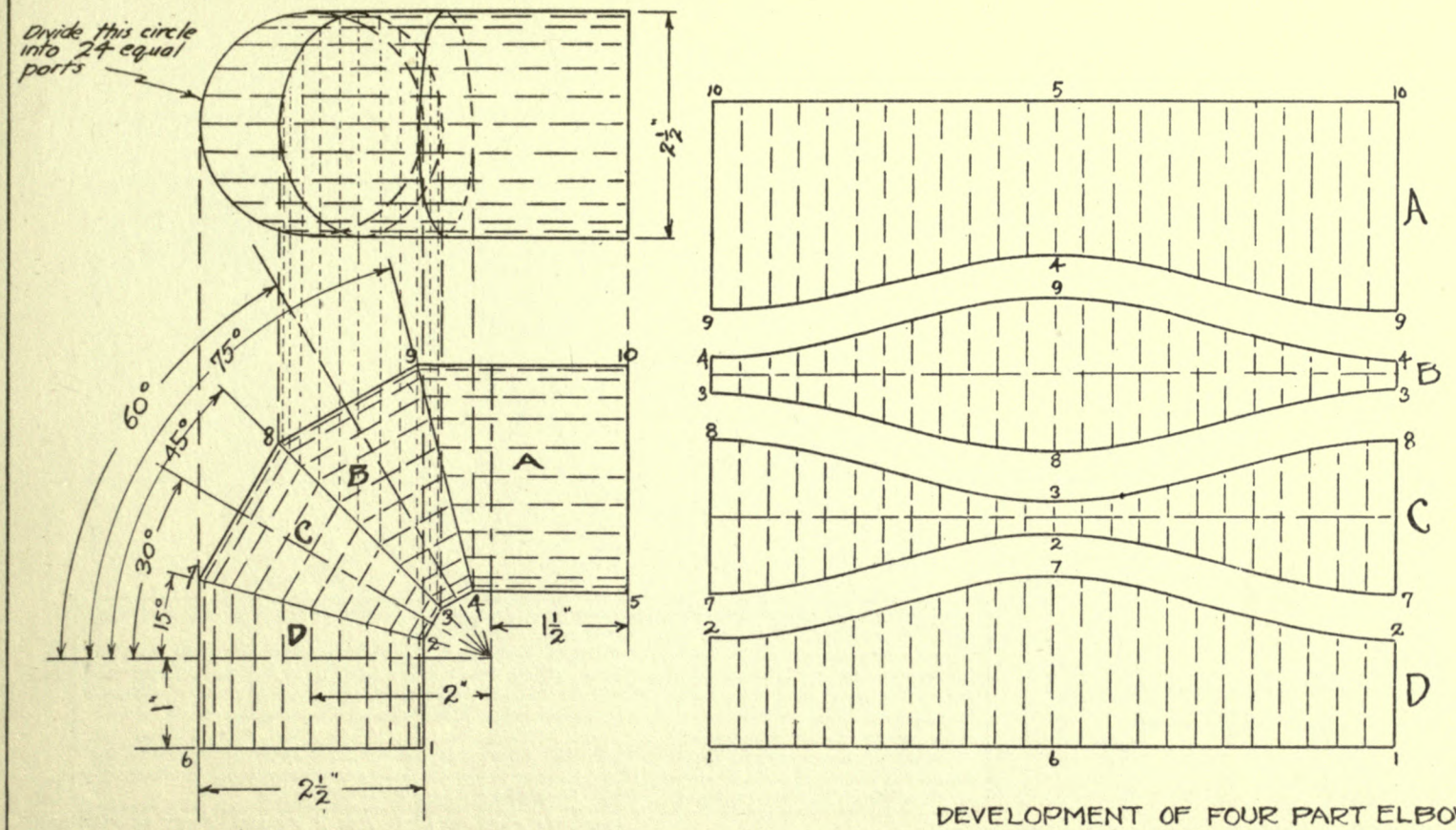
DEVELOPMENT OF CYLINDER CUT BY PLANE

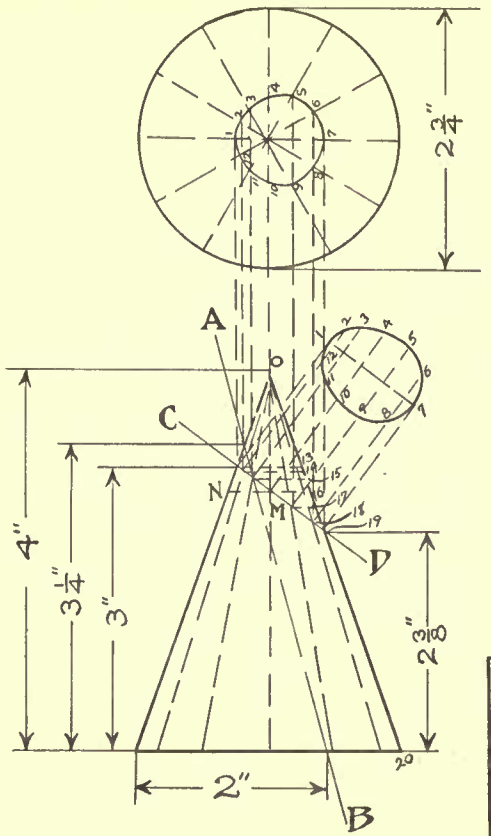
SCALE FULL SIZE.

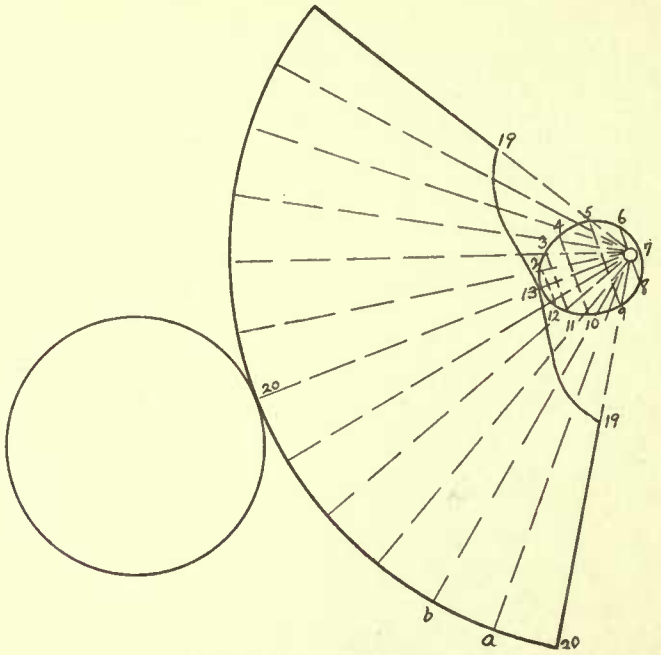
DRAWN BY

DATE

PLATE NO. 32


Divide this circle into 24 equal parts
2½"
60°
75°
45°
30°
15°
A
B
C
D
1½"
2"
1"
2½"
DEVELOPMENT OF FOUR PART ELBOW
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO. 33





Plates 34 and 35 require the representation of the development of a cone, after being cut by a plane in different positions. The same size cone is used in both cases.

Plate 34 should show the development of the object remaining after the cone has been cut by the plane CD. The development of this remaining object is here shown. The student should observe that the distance 4-10 in the top view equals twice the distance MN in the front view. He should also remember that all of the distances in the development from O to the curve 19-13-19 are obtained from the line O-20 in the front view and should not be measured on any other element.

Plate 35 - drawn on an entirely separate sheet - calls for a development of the object left after the cone has been cut by the plane A-B. The drawing of this exercise should demonstrate whether or not the student has mastered the principles presented by plate 34. The method of procedure is the same.

Instructions Draw top and front views of the cone as shown. Cut by plane CD for Plate 34 and by plane AB for Plate 35

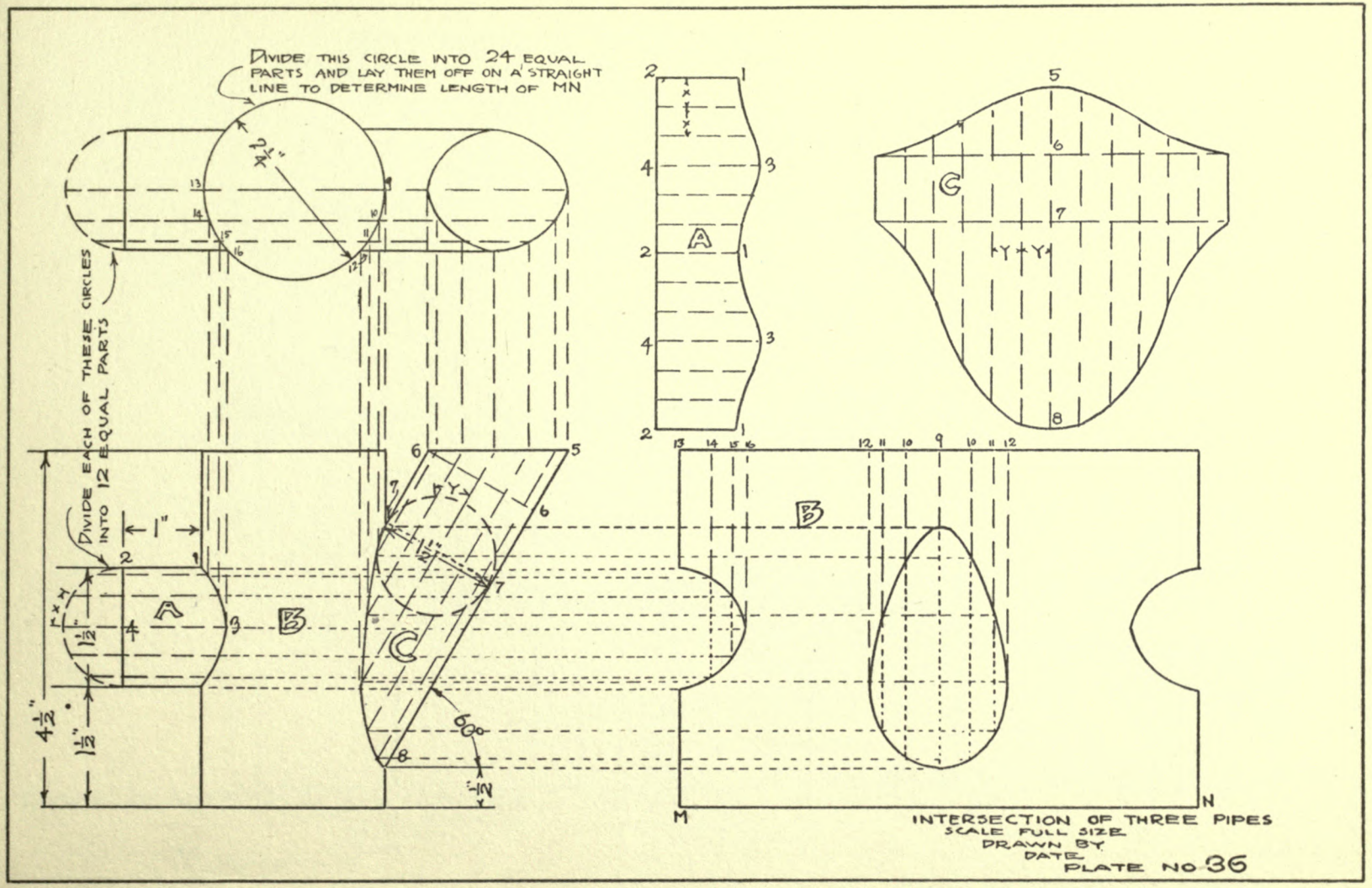
DEVELOPMENT OF A CONE CUT BY PLANE

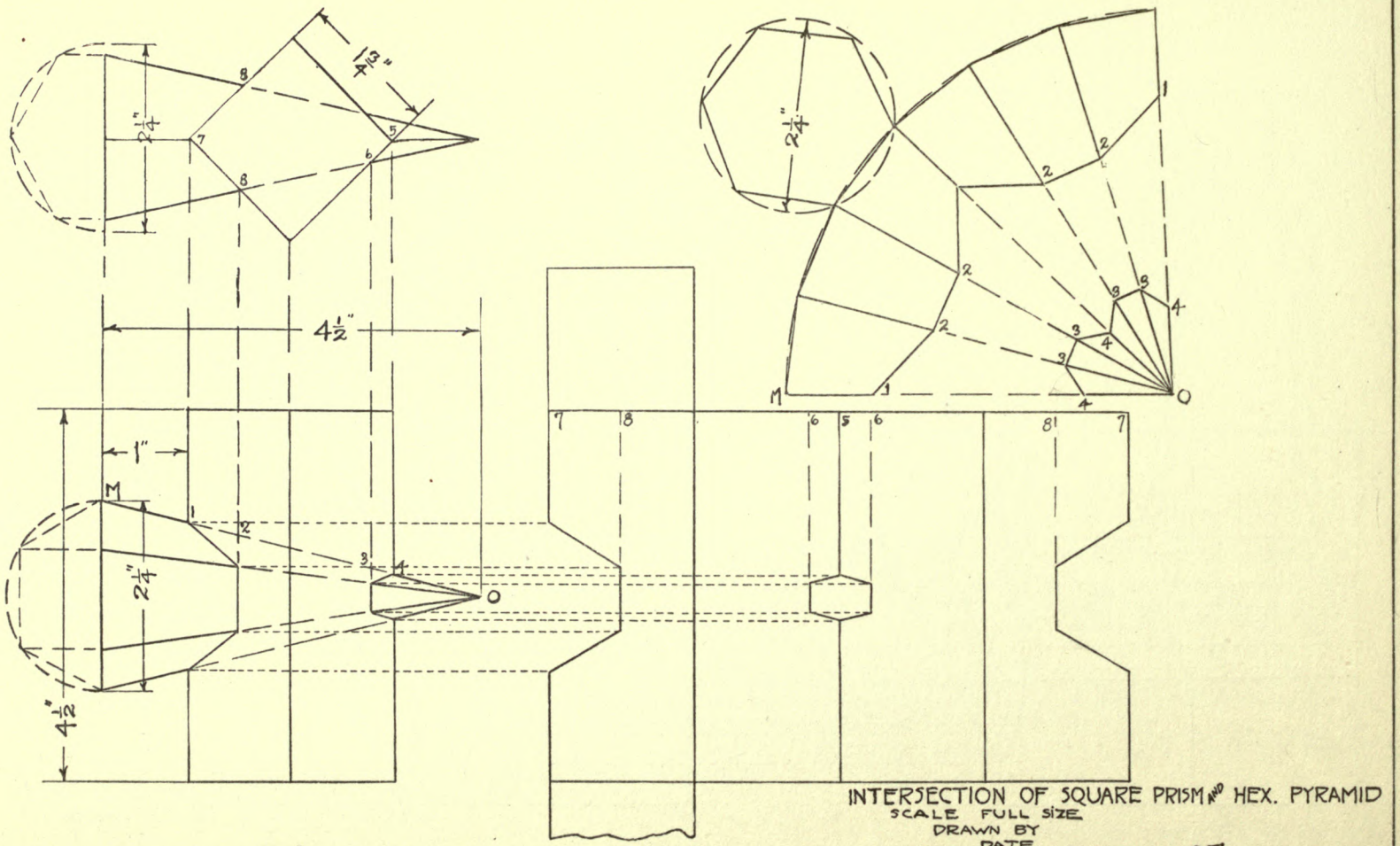
SCALE FULL SIZE

DRAWN BY

DATE

PLATES NO. 34 AND No. 35


DIVIDE THIS CIRCLE INTO 24 EQUAL PARTS AND LAY THEM OFF ON A STRAIGHT LINE TO DETERMINE LENGTH OF MN
DIVIDE EACH OF THESE CIRCLES INTO 12 EQUAL PARTS
A
B
C
60°
M
N
INTERSECTION OF THREE PIPES
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO 36



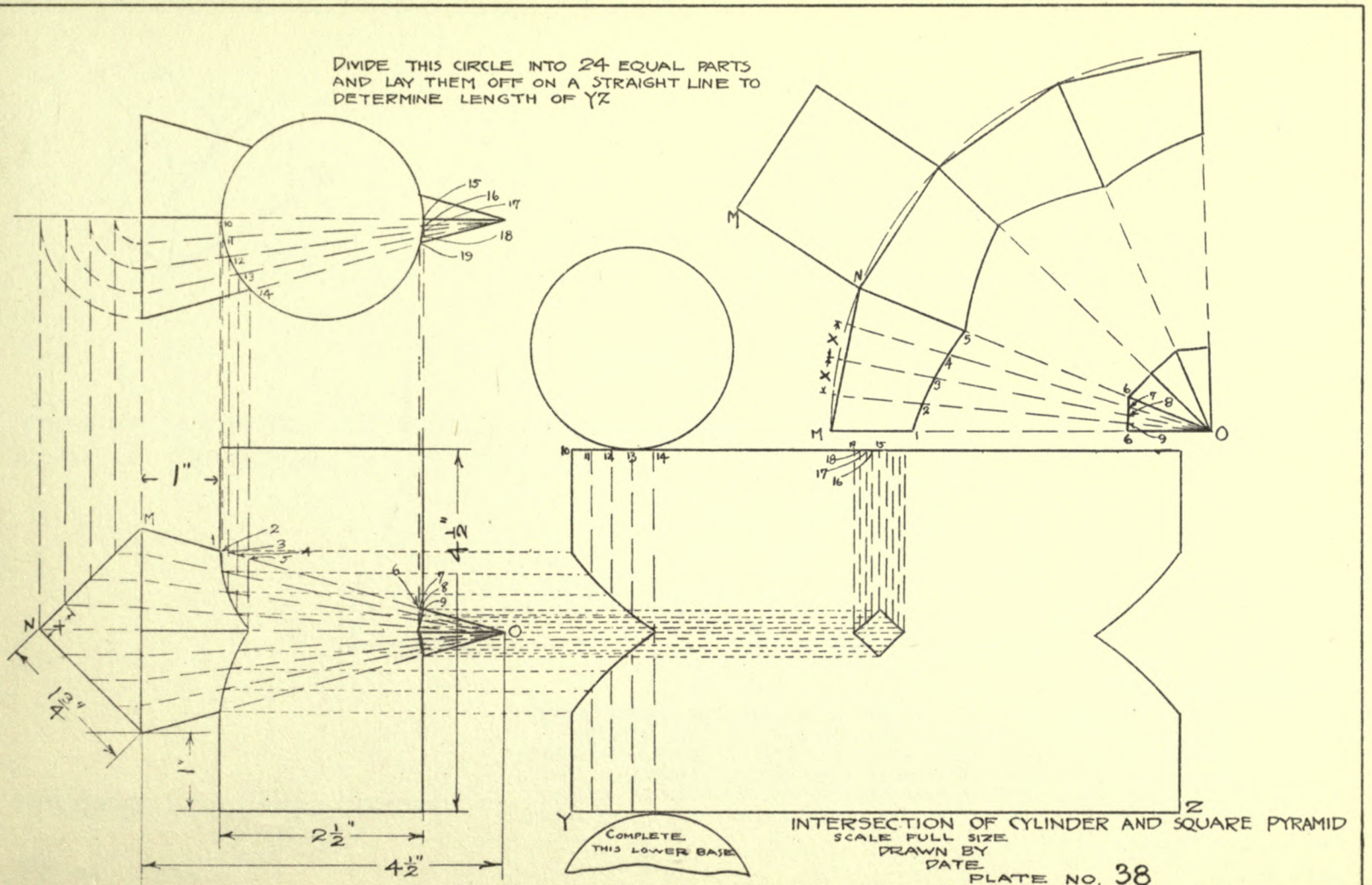
INTERSECTION OF SQUARE PRISM AND HEX. PYRAMID

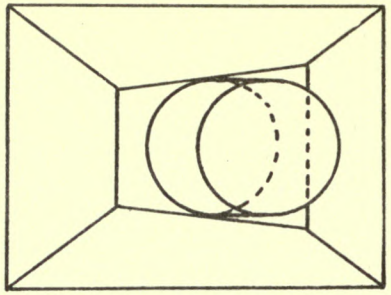
SCALE FULL SIZE

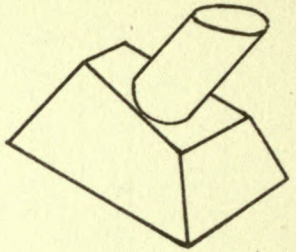
DRAWN BY

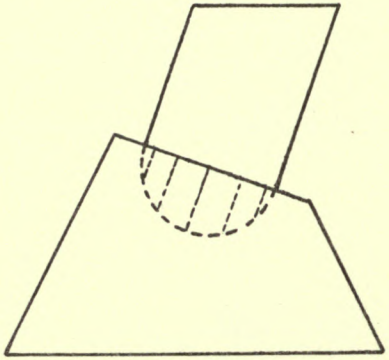
DATE

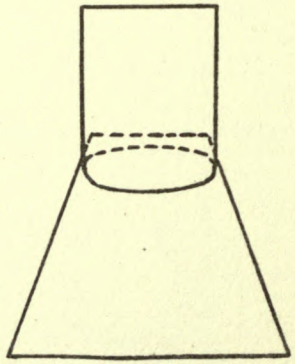
PLATE. NO. 37


DIVIDE THIS CIRCLE INTO 24 EQUAL PARTS AND LAY THEM OFF ON A STRAIGHT LINE TO DETERMINE LENGTH OF YZ
1"
4½"
2½"
4½"
1"
1 4½"
COMPLETE THIS LOWER BASE
INTERSECTION OF CYLINDER AND SQUARE PYRAMID
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO. 38









INSTRUCTIONS

TRANSFER THIS DRAWING TO THE REGULAR SIZE SHEET USING THE DIVIDERS AND MAKING THE DRAWING ON THE OTHER SHEET TWICE THE SIZE SHOWN HERE. DEVELOP THE OBJECT, CUT OUT THE DEVELOPMENTS AND PASTE THEM TOGETHER TO FORM THE OBJECT ILLUSTRATED IN THE UPPER RIGHT HAND CORNER. USE THIN PAPER. ALLOW LAPS FOR JOINTS.

DEVELOPMENT PROBLEM

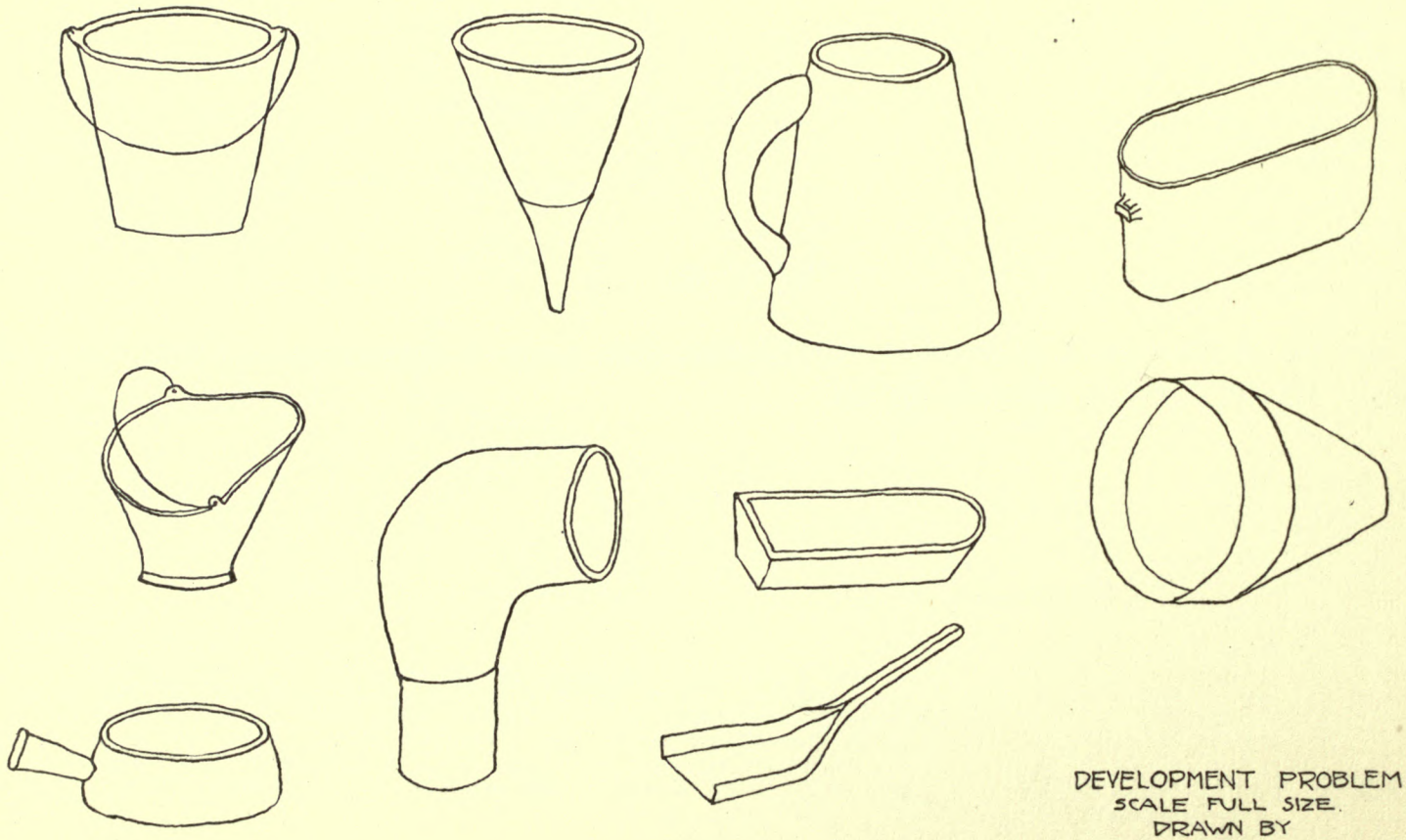
DRAWN BY

DATE

PLATE NO 39

PLATE 40.

Select any one of the objects sketched on the following page, draw its development full size, cut it out, and paste it together. Do not forget to allow for the lap.



DEVELOPMENT PROBLEM
SCALE FULL SIZE.
DRAWN BY
DATE.
PLATE NO. 40

DETAIL AND ASSEMBLY DRAWING.

The more practical work of the course begins with Plate 41. All work must be laid out in pencil first, and the pencil drawing must be just as complete as the finished drawing is to be. Neat work is exceedingly important. The appearance of the plate will depend much upon the way the lettering is done. Many sketches are given, but this does not imply that students are to make a sketch. Follow dimensions and make a finished drawing. Ink or trace according to directions. Students should study the several plates very carefully before proceeding with the work.

Pages 60 and 61 contain sketches of the objects drawn on the plates designated. These sketches should be carefully studied before and while drawing the object in orthographic projection.

Several plates require that a sketch be made of an object, the object measured, and the dimensions obtained to be put upon the sketch. This should be very carefully done, a particular effort being made to get all of the necessary dimensions on the sketch.

All assembly drawings must represent the very best skill of the student. Great care should be taken with the drawing of the different kinds of lines. No assembly drawing is to contain free-hand lettering. All letters must be drawn with the instruments.

When a drawing is to be traced stretch the tracing cloth over the drawing and ink in the same way as when a pencil drawing is inked. The dull side of the cloth is generally used.

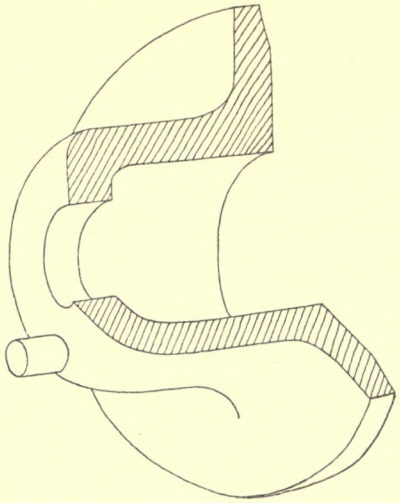


PLATE 41

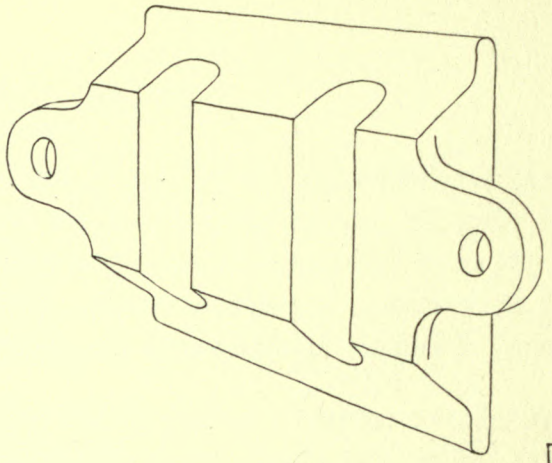


PLATE 42

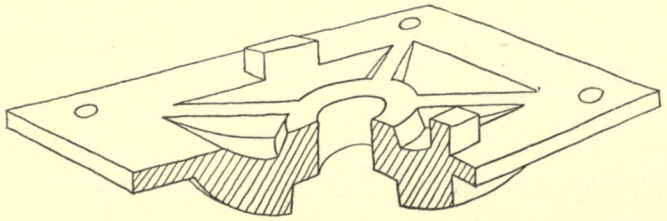


PLATE 43

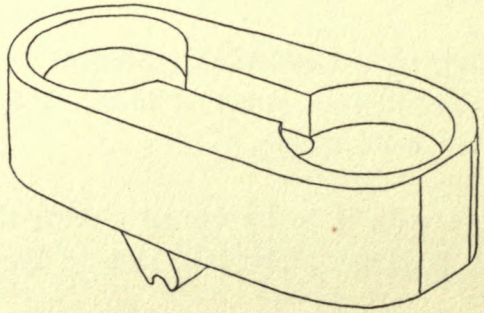


PLATE 44

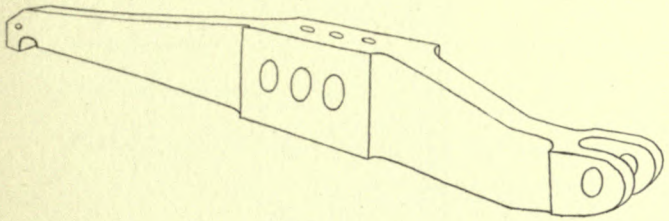


PLATE 45

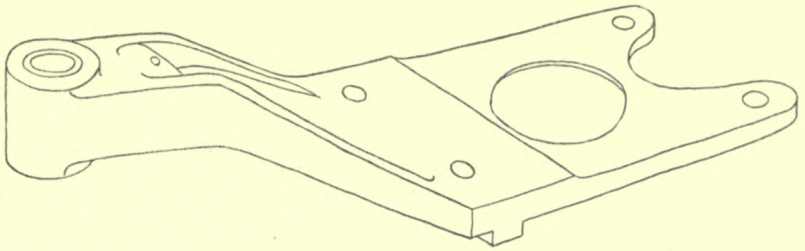


PLATE 46

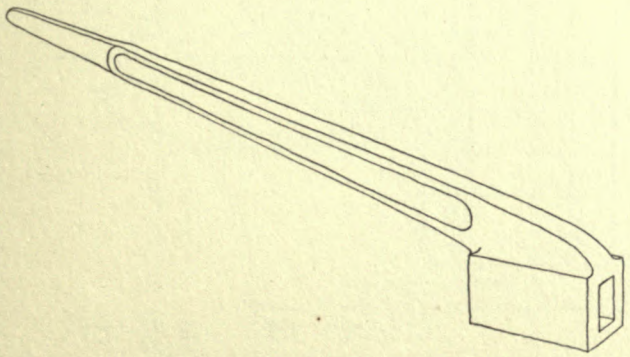


PLATE 47

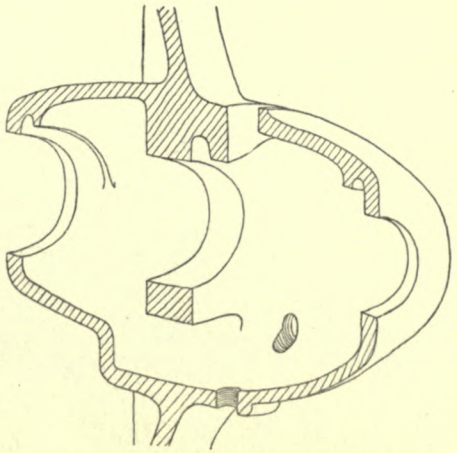
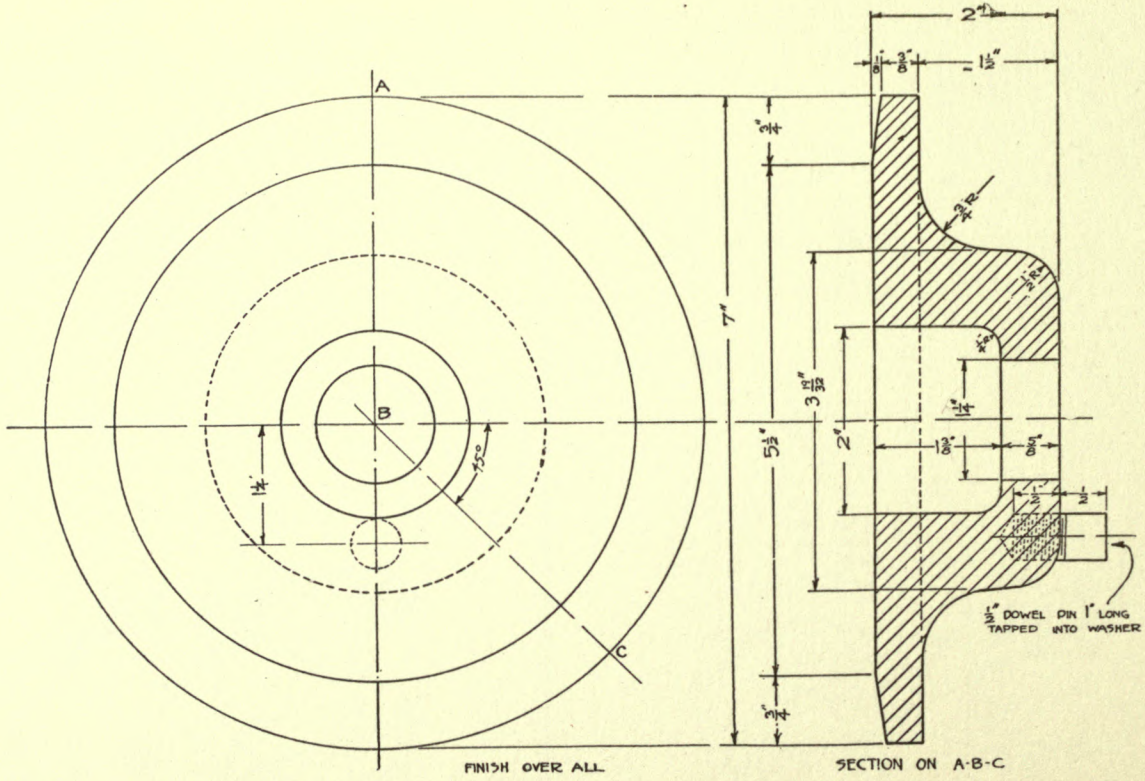


PLATE 48



Instructions *Make a pencil drawing and ink it*

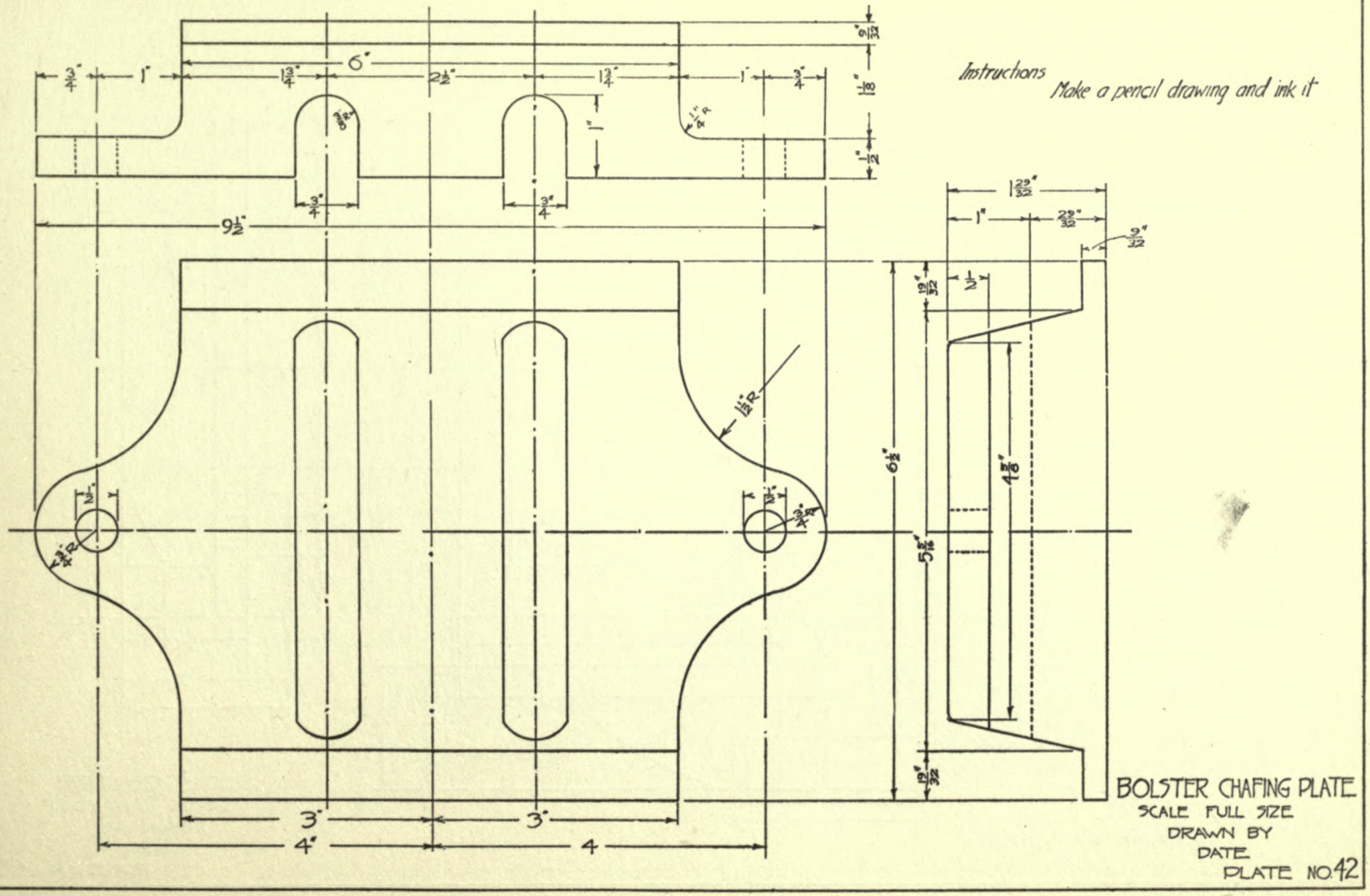
CRANK PIN WASHER

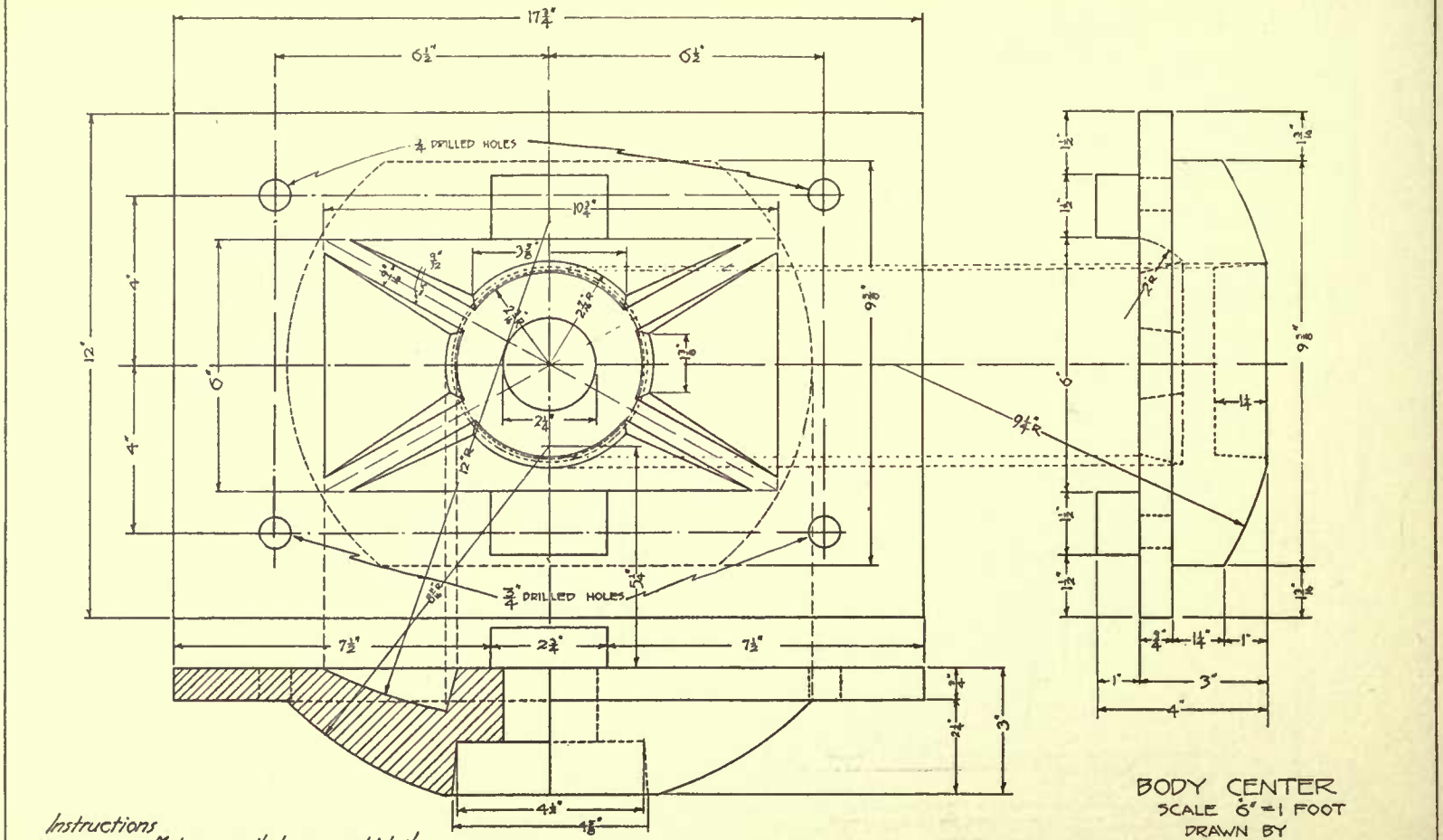
SCALE FULL SIZE

DRAWN BY

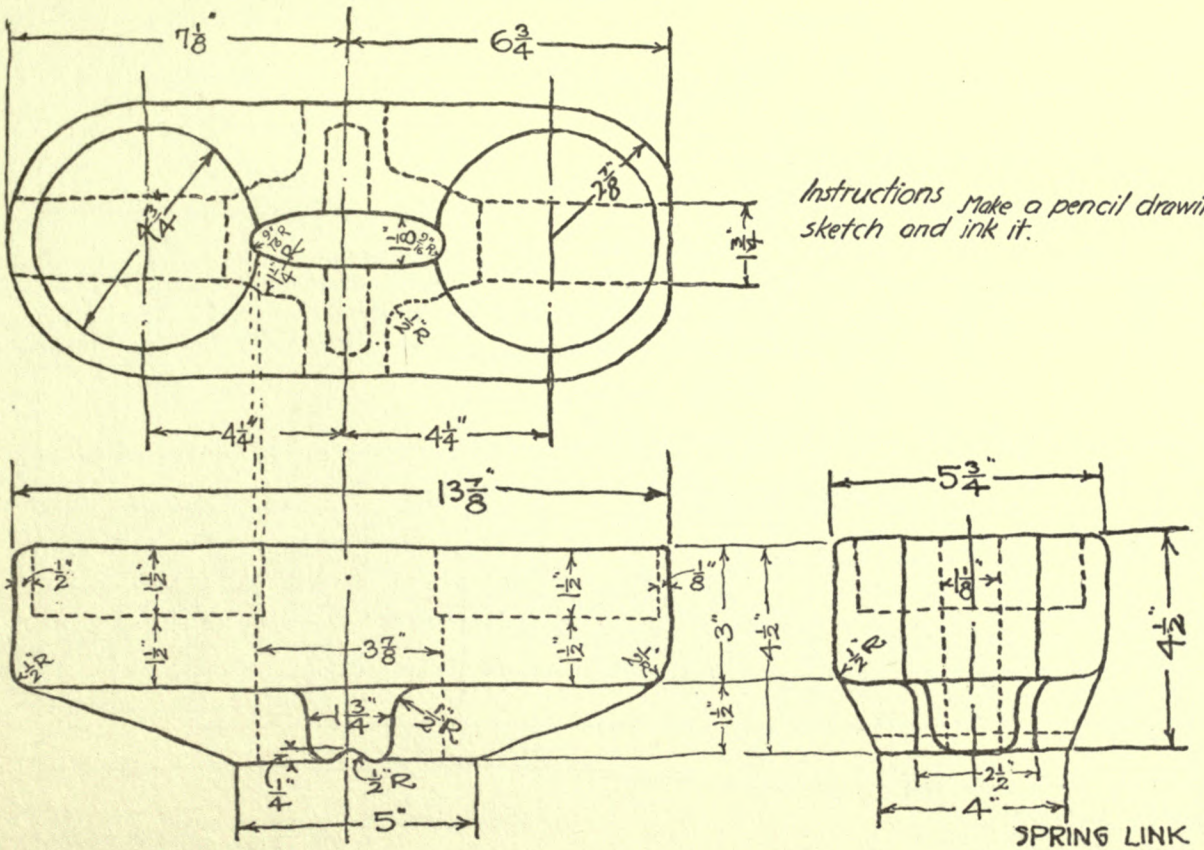
DATE

PLATE NO. 41


Instructions
Make a pencil drawing and ink it
6"
9½"
6½"
5⅝"
4"
3"
BOLSTER CHAFING PLATE.
SCALE FULL SIZE.
DRAWN BY
DATE
PLATE NO. 42



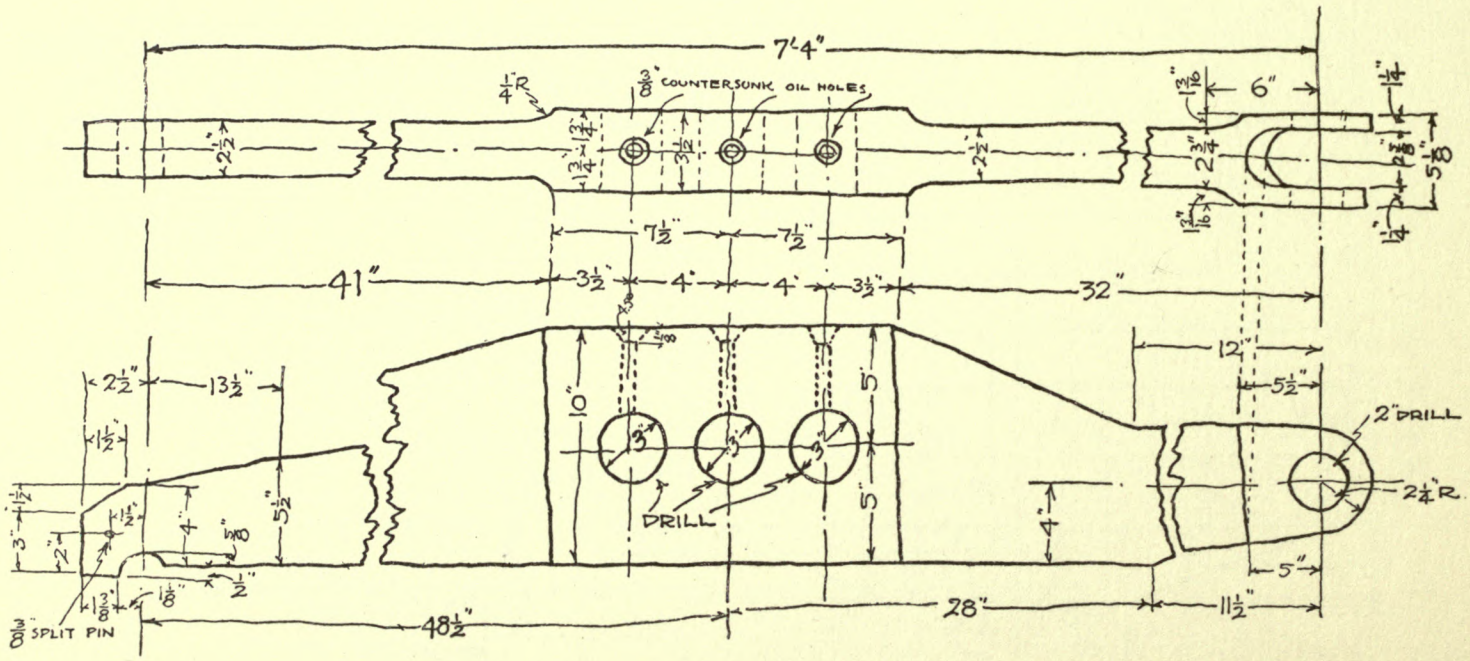
Instructions
Make a pencil drawing and ink it



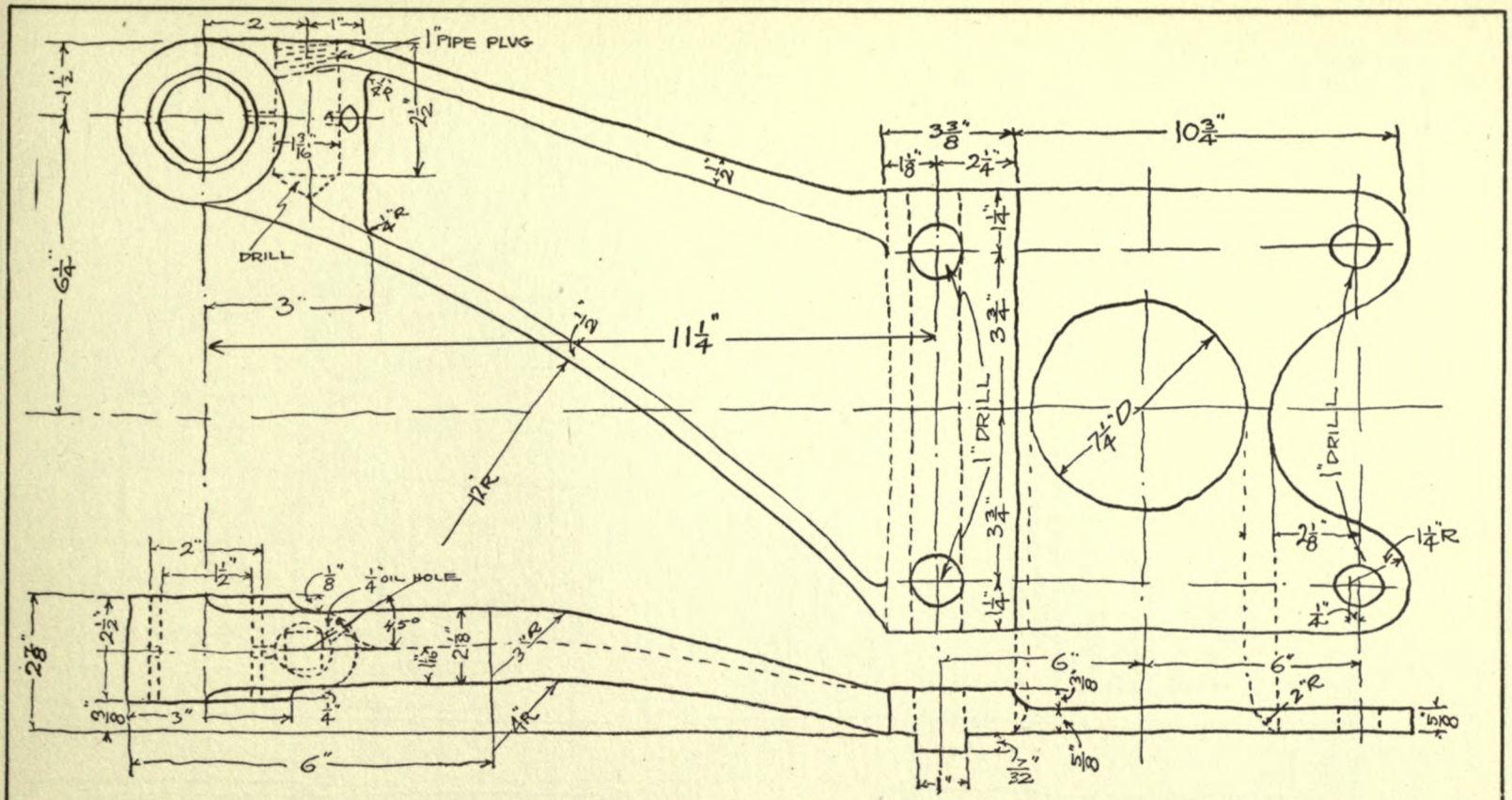
Instructions Make a pencil drawing of this sketch and ink it.

SPRING LINK SEAT
SCALE 6" = 1 FOOT
DRAWN BY
DATE
PLATE NO. 44

Instructions Make a pencil drawing of this sketch and ink it.

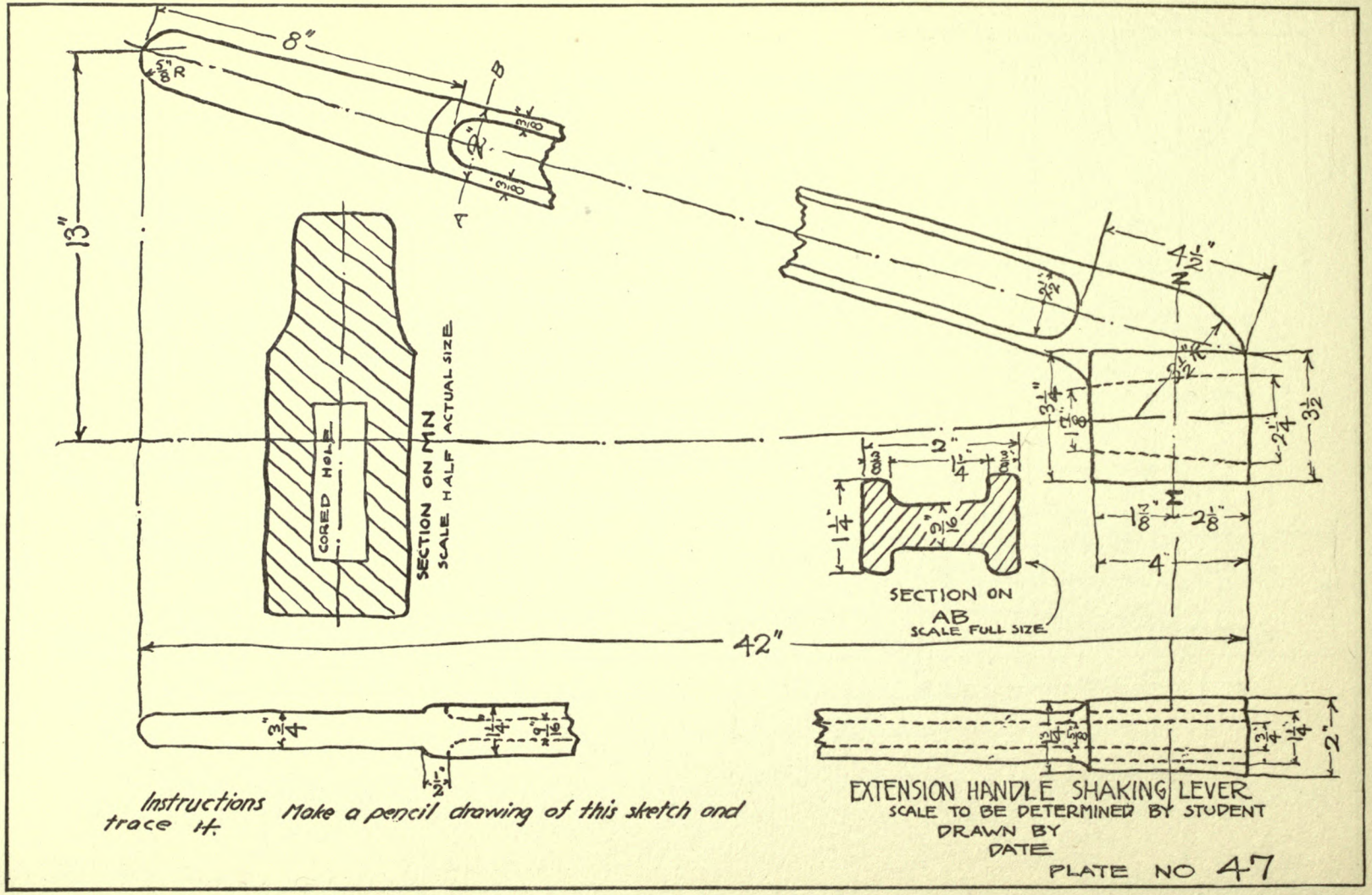


DETAIL OF CYLINDER EQUALIZER
SCALE 1½" = 1 FOOT
DRAWN BY
DATE
PLATE NO. 45

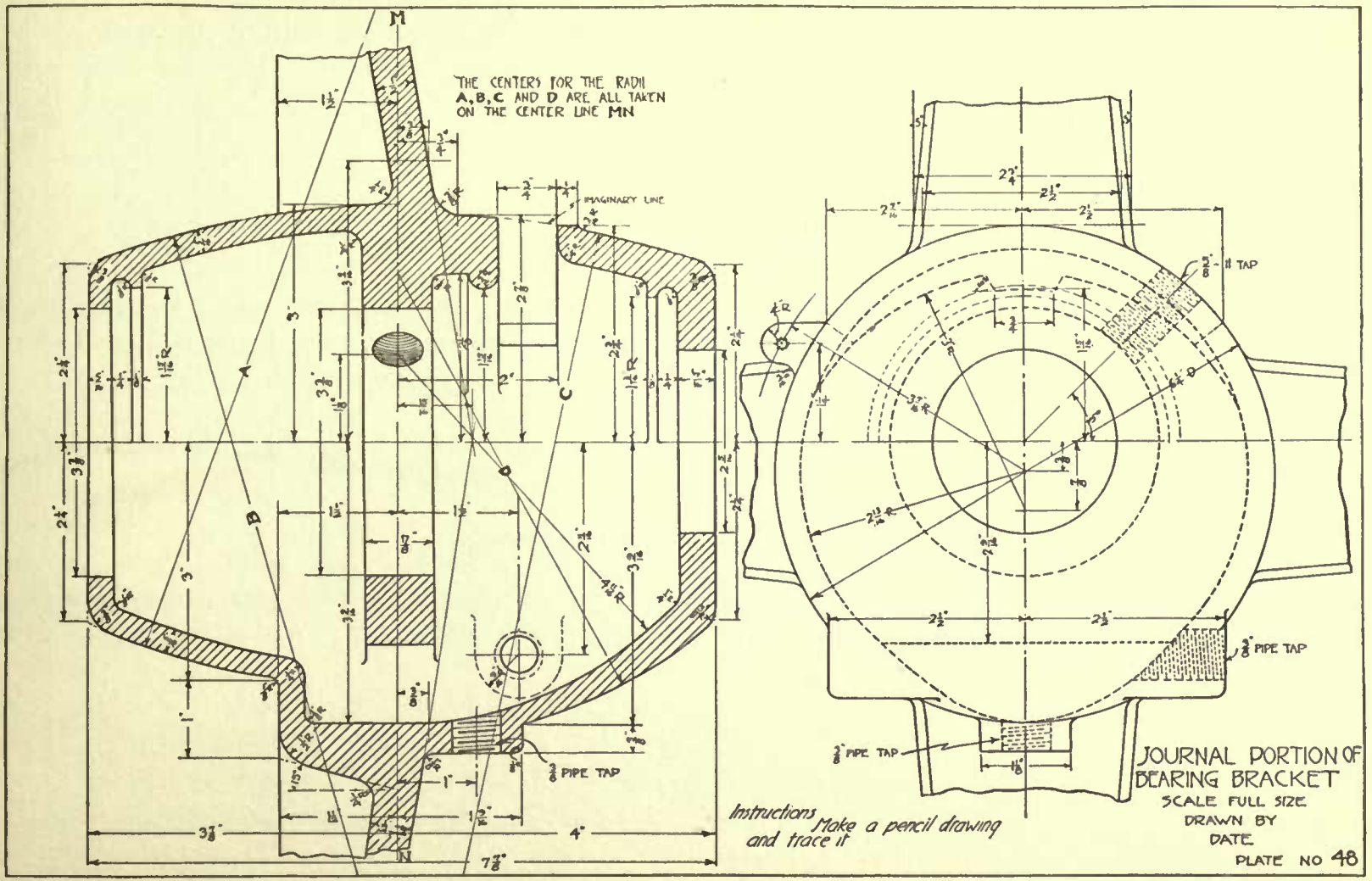


Instructions Make a pencil drawing of this sketch and trace it.

CROSSHEAD ARM
SCALE TO BE DETERMINED
DRAWN BY
DATE
PLATE NO. 46



Instructions Make a pencil drawing of this sketch and trace it.


THE CENTERS FOR THE RADII A, B, C AND D ARE ALL TAKEN ON THE CENTER LINE MN
M
N
IMAGINARY LINE
A
B
C
D
3/8 PIPE TAP
3/8 PIPE TAP
3/8 PIPE TAP
JOURNAL PORTION OF BEARING BRACKET
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO 48
Instructions Make a pencil drawing and trace it

SCREW THREADS.

It is frequently desirable in machine construction to fasten certain parts together in such a way that they can easily be put together and taken apart again without injury to the parts. This result is accomplished by using fastenings having screw threads cut upon them.

There are many different kinds of threads, the ones principally used being shown in cross section on Plate 49.

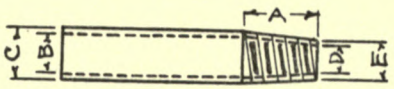
All of these plates are to be first drawn in pencil and afterwards inked.

The student is advised to study the chapter devoted to threads from some good book on Machine Design. The discussion of the subject is of such length that it is impossible to give space to it in this particular book.

TABLE OF SIZES OF TAP DRILLS.

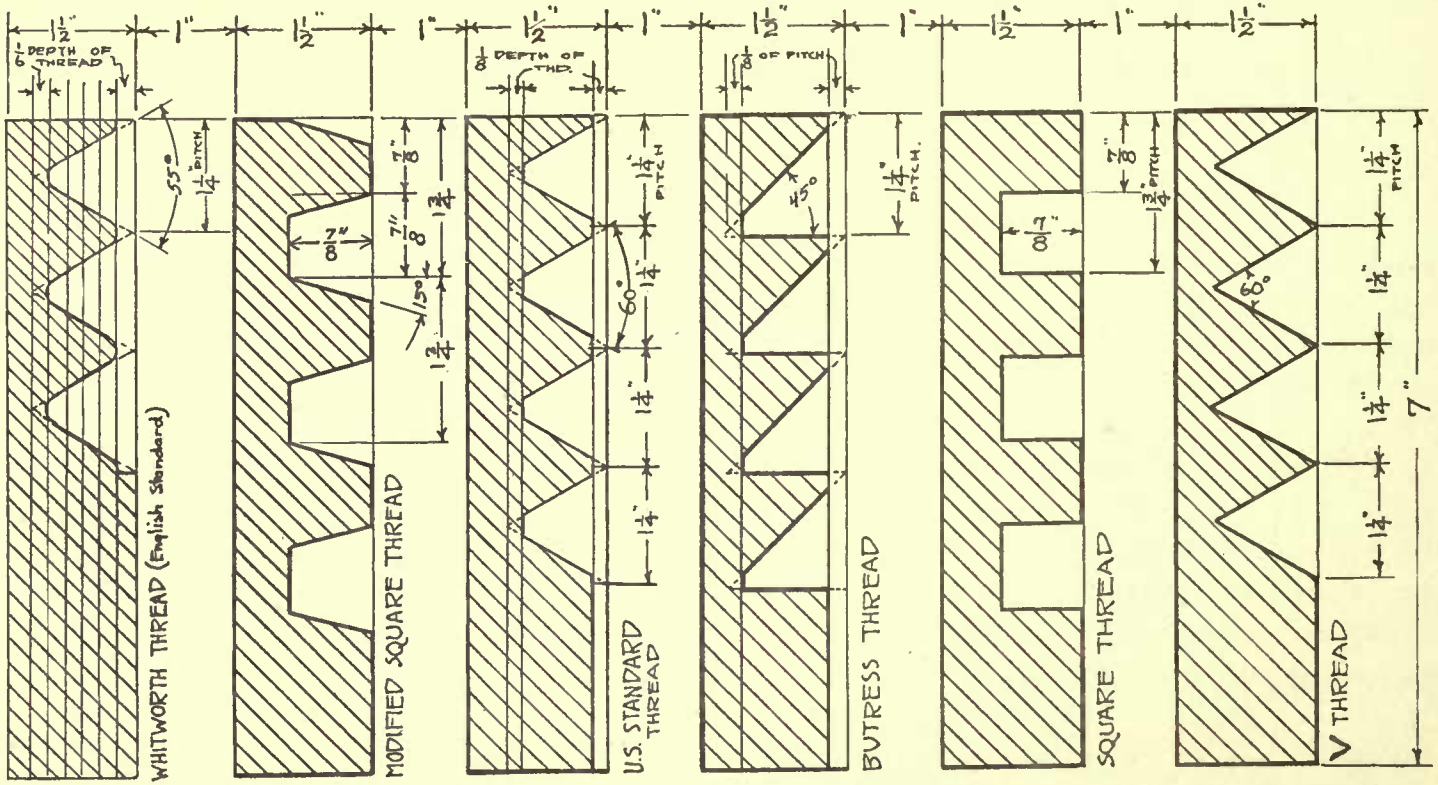
Tap Diameter Inches	Threads per Inch	Drill for V Thread	Drill for U. S. Standard	Drill for Whitworth
1-4	16, 18, 20	5-32, 5-32, 11-64	3-16	3-16
9-32	16, 18, 20	3-16, 13-64, 13-64		
5-16	16, 18	7-32, 15-64	1-4	15-64
11-32	16, 18	1-4, 17-64		
3-8	14, 16, 18	1-4, 9-32, 9-32	9-32	9-32
13-32	14, 16, 18	19-64, 21-64, 21-64		
7-16	14, 16	21-64, 11-32	11-32	11-32
15-32	14, 16	23-64, 3-8		
1-2	12, 13, 14	3-8, 25-64, 25-64	13-32	3-8
9-16	12, 14	7-16, 29-64	7-16	
5-8	10, 11, 12	15-32, 1-2, 1-2	1-2	1-2
11-16	11, 12	9-16, 9-16		
3-4	10, 11, 12	19-32, 5-8, 5-8	5-8	5-8
13-16	10	21-32		
7-8	9, 10	45-64, 23-32	23-32	23-32
15-16	9	49-64		
1	8	13-16	27-32	27-32

WROUGHT IRON PIPE THREAD.



Size of Pipe Inches	B	C	E	D	A	Threads per Inch
1-8	.27	.40	.39	.33	.19	27
1-4	.36	.54	.52	.43	.29	18
3-8	.49	.67	.66	.57	.30	18
1-2	.62	.84	.82	.70	.39	14
3-4	.82	1.05	1.03	.91	.4	14
1	1.05	1.31	1.28	1.14	.51	11 1-2
1 1-4	1.38	1.66	1.63	1.49	.54	11 1-2
1 1-2	1.61	1.9	1.87	1.73	.55	11 1-2
2	2.07	2 3-8	2.34	2.2	.58	11 1-2
2 1-2	2.47	2 7-8	2.82	2.62	.89	8
3	3.07	3 1-2	3.44	3.24	.95	8
3 1-2	3.55	4	3.94	3.74	1	8

Size of pipe is inside diameter. D=diameter at bottom of the thread. B=inside diameter of pipe. C=outside diameter.



SCREW THREADS
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO. 49

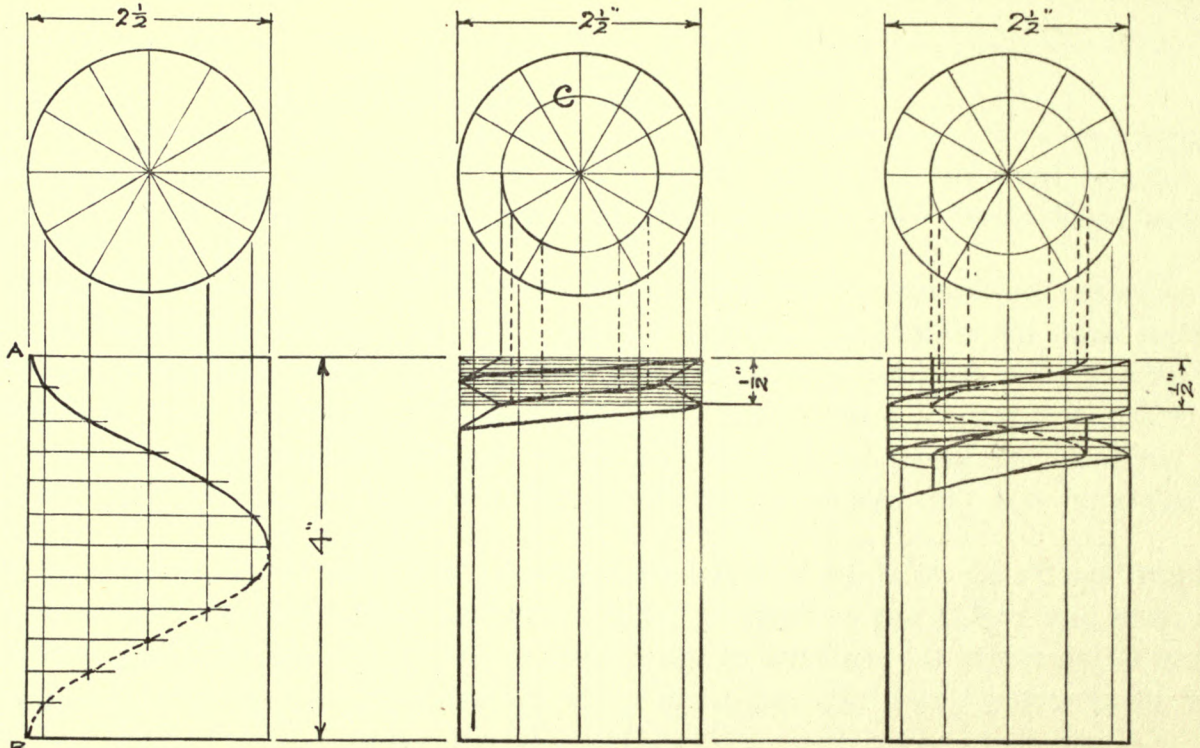
INSTRUCTIONS FOR PLATE 50.

Draw the top and front views of three cylinders well spaced upon the sheet. Divide each of the circumferences into twelve equal parts. This is easily done by using the 30-60 triangle.

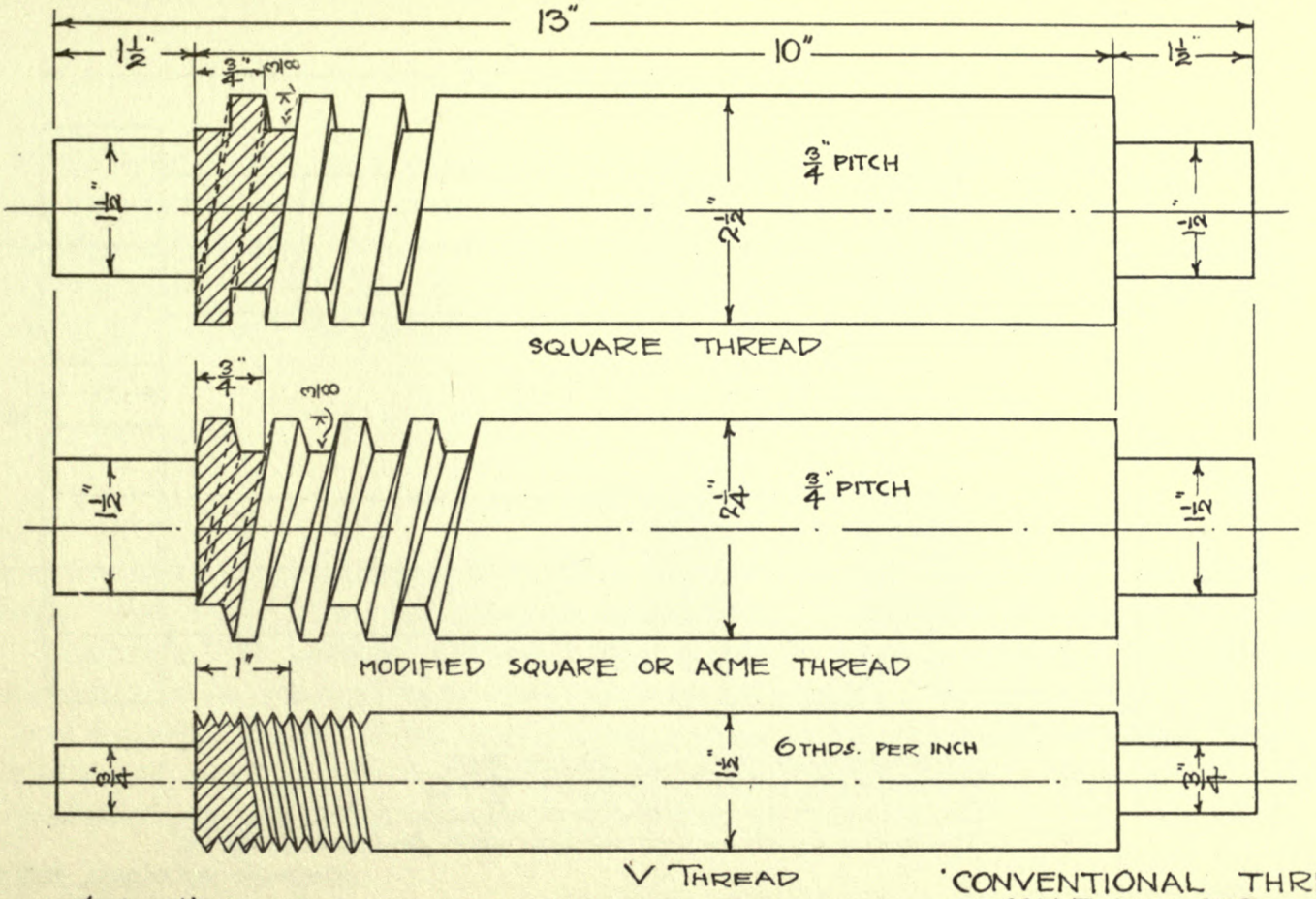
Figure 1 represents the drawing of the curve called the helix. This curve is generated by a point moving in a horizontal direction upon the surface of a moving cylinder. The point of a threading tool in a lathe will generate a helix upon the moving piece of metal from which the thread is to be made. The distance from A to B represents the pitch of the thread, and this must be divided into exactly the same number of parts as contained in the circumference. This is twelve in this particular case. Project down from the points on the circumference intersecting lines drawn from the points on A B. By connecting the intersections the points of the helix may be obtained.

Figure 2 shows how the curves of the V thread are obtained. The pitch in this instance is $\frac{1}{2}''$. This is divided into twelve equal parts just as A B was in Figure 1. The intersections are obtained in the same way. Note that the inner circumference C represents the diameter at the bottom of the thread, and that the curve of the bottom of the thread is obtained by projecting down from the points where the diameters cut this circumference.

Figure 3 gives the curves of the square thread. Apply the principles used in the preceding figures to obtain the curves. The pitch of the thread in this case is one inch.

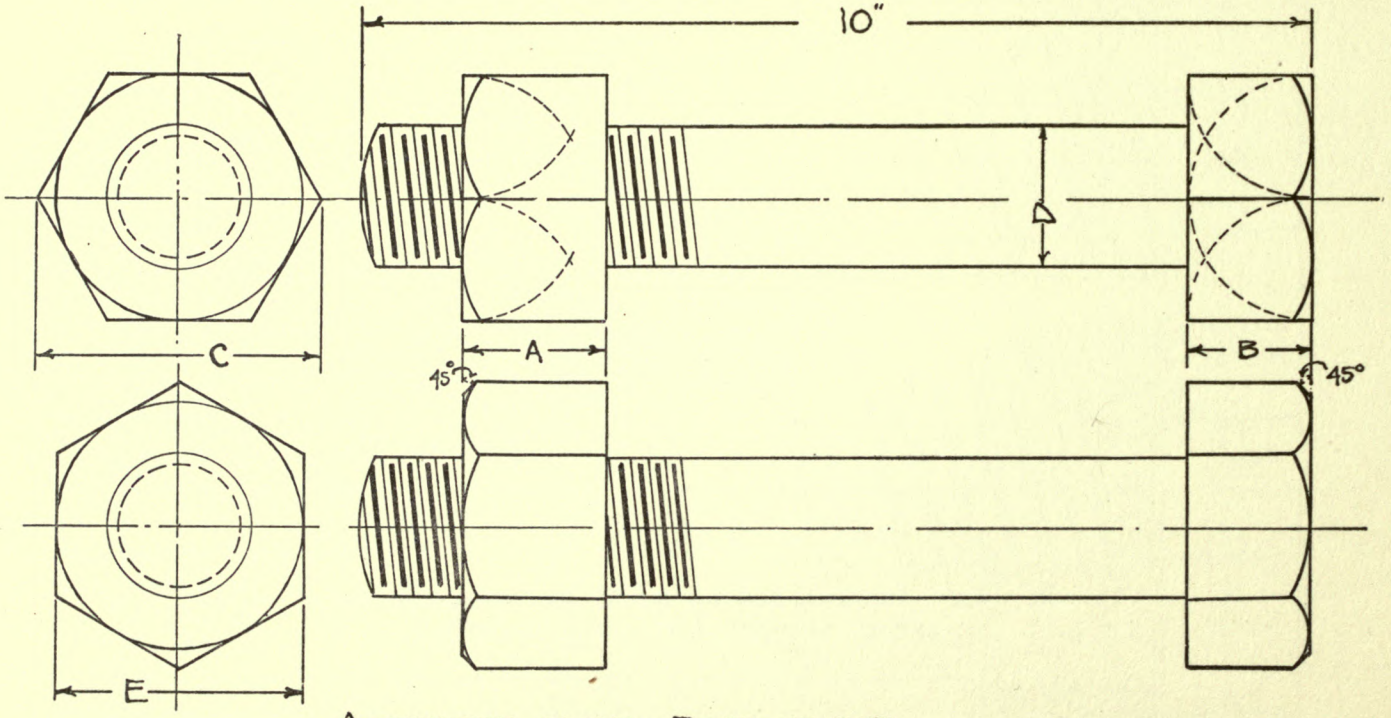


THE HELIX AND ITS APPLICATION
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO 50



Instructions Lay out sheet in pencil and ink. Draw cross sections as on Plate 49 and connect points obtained in order to obtain views as shown above.

'CONVENTIONAL THREADS
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO. 51



A = THICKNESS OF NUT = D = DIA. OF BOLT
B = THICKNESS OF HEAD OF BOLT = $\frac{3D}{4} + \frac{1}{16}$"
C IS OBTAINED BY CONSTRUCTING HEXAGON
E = DISTANCE BETWEEN PARALLEL SIDES OF HEXAGON = $\frac{3D}{2} + \frac{1}{8}$"

Instructions Take $D = 1\frac{1}{2}$" and compute all other dimensions
This plate is to be inked.

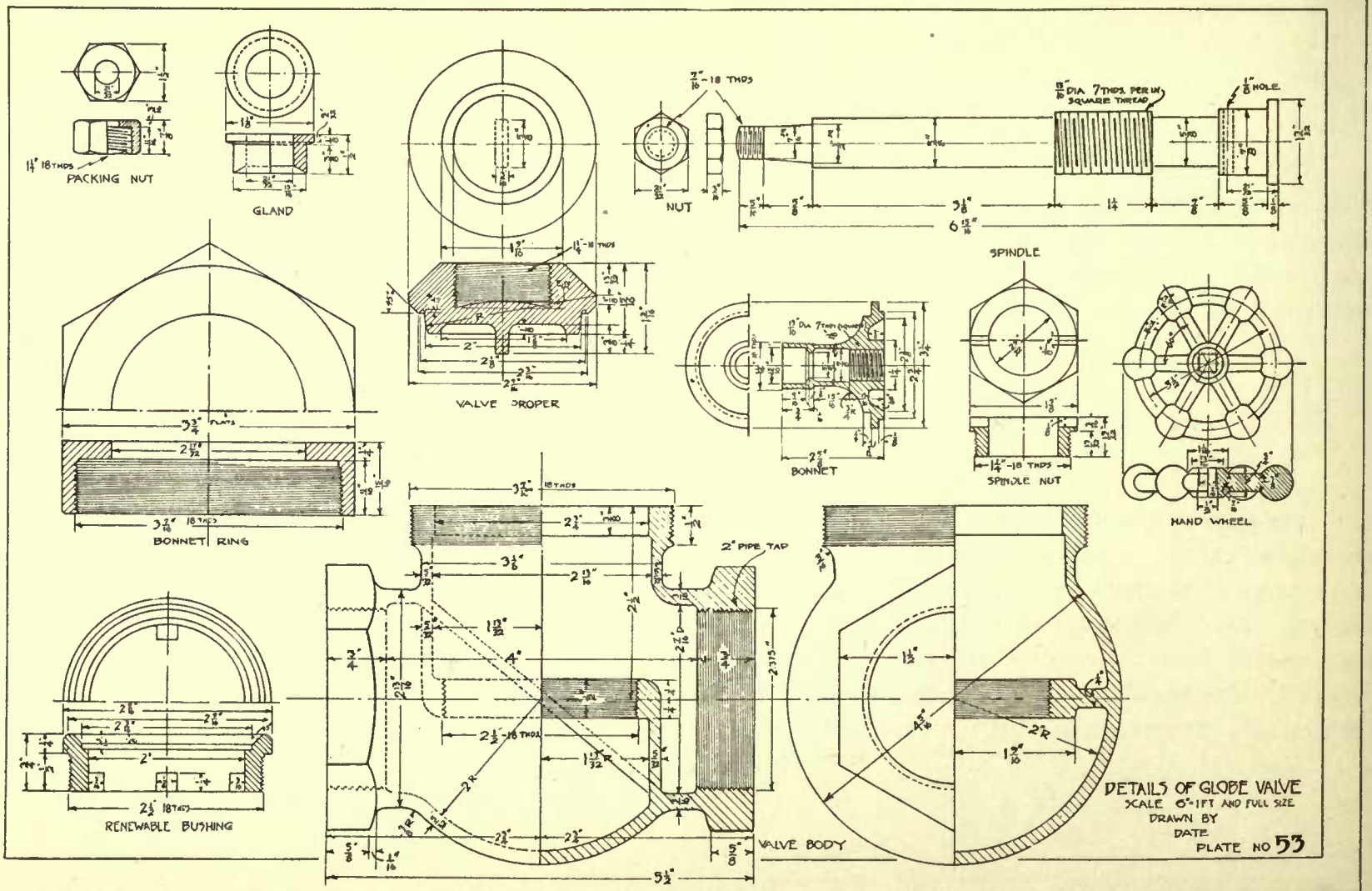
STANDARD HEXAGONAL BOLT AND NUT
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO. 52

PLATE 53.

Details of the several parts of a globe valve are here shown. A finished drawing from these details is to be made and the penciled drawing traced. The location of the parts upon the sheet should be determined upon before starting. Use considerable care in dimensioning. Do not trace the drawing until the assembly is completed. Every detail drawing should have lettered on it the material of which the piece is made, the surfaces to be finished (machined) denoted by "f," and the number of each part wanted to make a complete whole.

PLATE 54.

As soon as the penciled detail drawing of the globe valve is completed, from these details make an assembly drawing as shown. Half is in section, half shows an outside view. This should be executed on a good grade of white paper ("Whatman's," for example), and every effort should be made to produce a particularly well finished drawing. There should be no free-hand work at all, not even the lettering. The reason why it is advisable to make the assembly from the pencil drawing of the details is that a check on the accuracy of the several details can thus be obtained. The parts will not fit together to make the whole if they are not correct. The size of the sheet is $14\frac{1}{2}''$ x $20\frac{1}{2}''$ outside dimensions, one-inch border.


PACKING NUT
GLAND
VALVE PROPER
NUT
SPINDLE
BONNET
SPINDLE NUT
HAND WHEEL
BONNET RING
RENEWABLE BUSHING
VALVE BODY
2" PIPE TAP
DETAILS OF GLOBE VALVE
SCALE 6"=1FT AND FULL SIZE
DRAWN BY
DATE
PLATE NO 53

GLOBE VALVE.

SCALE FULL SIZE

DRAWN BY L GOLDSMITH

PLATE NO. 54

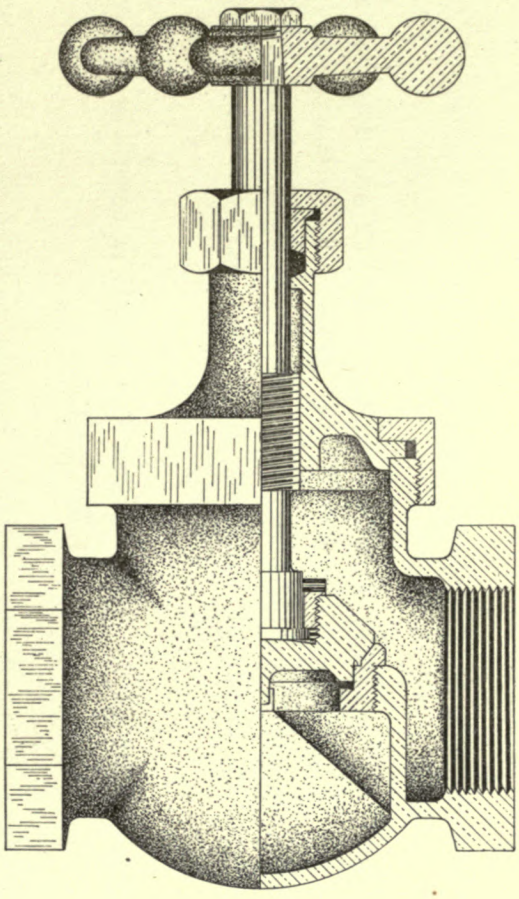


PLATE 55.

For this Plate the student will be given a casting of some kind or any detail of a machine of a fairly complicated nature and be required to make a proper sketch of the same fully dimensioned. The dimensions will have to be obtained by actual measurement. The sketch should be very carefully made, and an extreme effort should be made to get all dimensions, properly arranged, thereon. From this sketch a pencil drawing is to be made which in turn is to be traced.

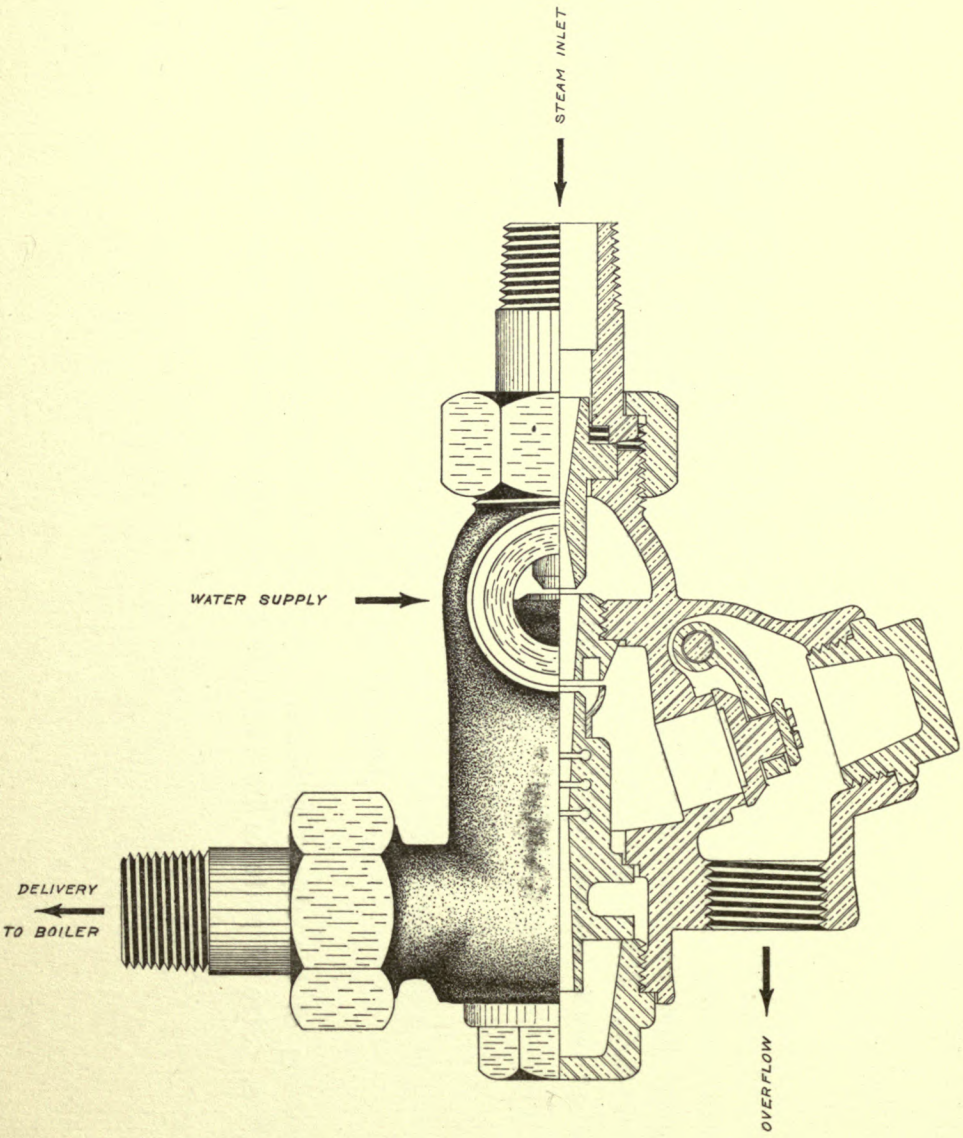
Obviously the final drawing cannot be made unless the sketch is complete in every detail.

PLATE 56.

A more complicated object should be selected for this drawing than that covered by Plate 55. The injector, as represented by the assembly drawing on Page 82, makes an excellent thing because of the number and shape of the details. Measurements must first be taken and sketches made. These sketches must be complete, especially as far as dimensions are concerned. The pencil detail drawing is to be made from the sketches. There is to be but one sheet of details, and the proper scales must be selected so that this can be done. The injector here given is a "Lukenheimer."

PLATE 57.

Make an assembly drawing of the object selected. Half to be shown in section, half an outside view. No free-hand lettering on this plate. Size of plate to be $14\frac{1}{2}'' \times 20\frac{1}{2}''$ outside dimensions with a one-inch border.



AUTOMATIC INJECTOR

SCALE - TWICE ACTUAL SIZE

DRAWN BY G.W. LUCAS.

JANUARY 12, 1914

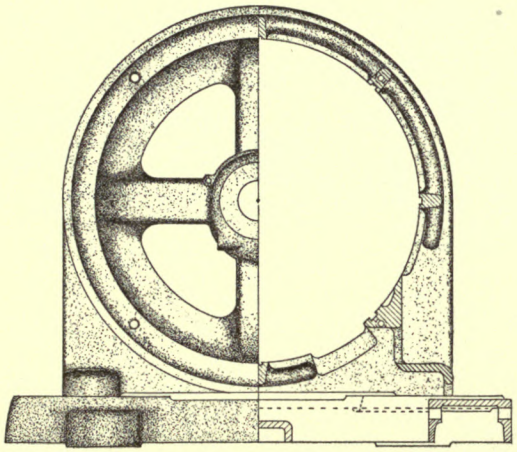
PLATE NO. 57

PLATE 58.

Sketch a lathe, a motor, a steam engine, or some similar object, and draw the front and side views of it. This must be very well done. No free-hand lettering is allowed. The sheet is to be $20\frac{1}{2}'' \times 29''$ outside dimensions, with a $1\frac{1}{4}''$ border. An idea of what is wanted can be obtained from the following drawing on Page 84. Draw this on white paper ("Whatman's" is suggested) and ink it.

ASSEMBLY OF INDUCTION MOTOR.

SCALE THREE INCHES = ONE FOOT.
DRAWN BY E O PATCH.
NOV. 4, 1914.
PLATE NO. 58.



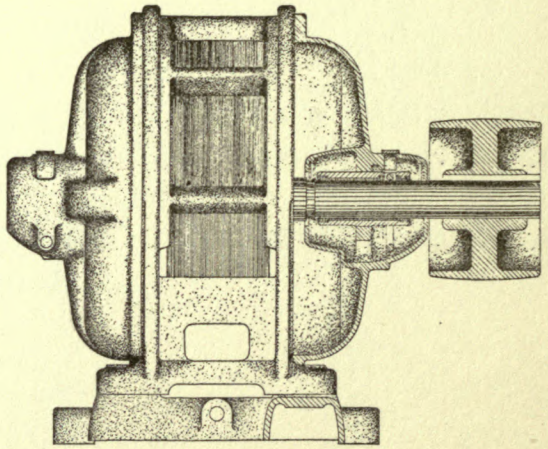
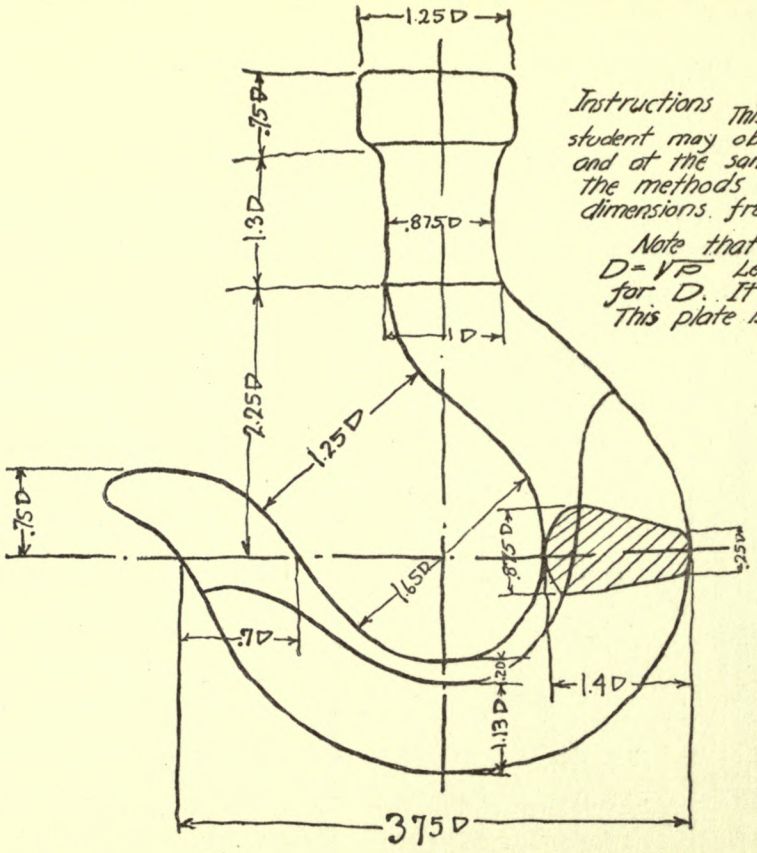


TABLE OF DECIMAL EQUIVALENTS

of

8ths, 16ths, 32ds, and 64ths of an inch

8ths		16ths		32ds		64ths	
1-8	= .125	1-16	= .0625	1-32	= .03125	1-64	= .015625
1-4	= .250	3-16	= .1875	3-32	= .09375	3-64	= .046875
3-8	= .375	5-16	= .3125	5-32	= .15625	5-64	= .078125
1-2	= .500	7-16	= .4375	7-32	= .21875	7-64	= .109375
5-8	= .625	9-16	= .5625	9-32	= .28125	9-64	= .140625
3-4	= .750	11-16	= .6875	11-32	= .34375	11-64	= .171875
7-8	= .875	13-16	= .8125	13-32	= .40625	13-64	= .203125
		15-16	= .9375	15-32	= .46875	15-64	= .234375
				17-32	= .53125	17-64	= .265625
				19-32	= .59375	19-64	= .296875
				21-32	= .65625	21-64	= .328125
				23-32	= .71875	23-64	= .359375
				25-32	= .78125	25-64	= .390625
				27-32	= .84375	27-64	= .421875
				29-32	= .90625	29-64	= .453125
				31-32	= .96875	31-64	= .484375
						33-64	= .515625
						35-64	= .546875
						37-64	= .578125
						39-64	= .609375
						41-64	= .640625
						43-64	= .671875
						45-64	= .703125
						47-64	= .734375
						49-64	= .765625
						51-64	= .796875
						53-64	= .828125
						55-64	= .859375
						57-64	= .890625
						59-64	= .921875
						61-64	= .953125
						63-64	= .984375



Instructions This design is required so that the student may obtain an idea of proportion and at the same time familiarize himself with the methods necessary in order to change dimensions from decimal to fractional form

Note that all dimensions are proportions of D $D = \sqrt{P}$ Let P in this case = 2 tons and solve for D. It is obvious that D will equal $\sqrt{2}$. This plate is to be drawn in pencil and inked.

CRANE HOOK.
SCALE FULL SIZE.
DRAWN BY
DATE
PLATE NO. 59

PLATE 60. THE CYCLOID.

If a mark was made upon the circumference of a circle at the exact point of contact with a plane, the mark, as the circle revolved along the plane, would follow a curve called the cycloid.

To generate this curve, draw any circle, as D E F, and divide its circumference into any number of equal parts (in this case use twelve). Draw a straight line tangent to the circle at F, and on it lay off six divisions, each equal to a division of the circle. From a, b, c, d, e, and f draw perpendiculars cutting the center line of the circle. Taking these points as centers, swing arcs. On these arcs lay a-6 equals one division of the circle; b-7 equals two divisions; and so on until point 11 is obtained. Connect the points to obtain the curve. Draw the circle D E F two inches in diameter.

THE ARCHIMEDEAN SPIRAL.

The spiral is a curve which makes one or more revolutions round a fixed point, but does not return to itself.

To construct the Archimedean Spiral, draw any circle and divide it into any number of equal parts. Divide the radius into the same number of equal parts, and draw concentric circles through these points of division. The intersections of these circles with the diameters will give the points of the spiral. Connect 1, a, b, c, d, e, f, g, h, k, m, and n to obtain the curve. Take 1-7 in this case as five inches.

THE INVOLUTE.

If a perfectly flexible line was wound round any curve and kept stretched as it was gradually unwound, any point in the line would trace another curve called the involute of the curve.

Draw any circle (in this instance two inches in diameter) and divide it into any number of equal parts. Draw tangents to the circle at each point of division. a-2 equals one division of the circle; b-3 equals two divisions, and so on. Connect the points obtained for the desired curve.

THE CYCLOID

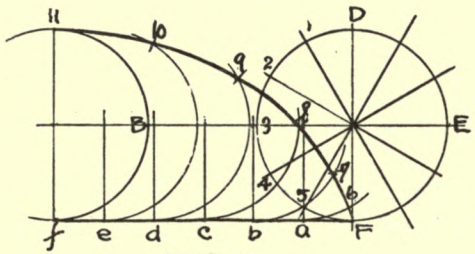


FIG. 1

THE ARCHIMEDEAN SPIRAL

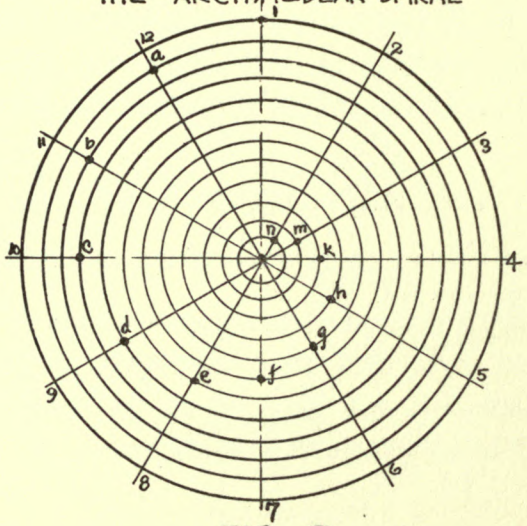


FIG. 2

THE INVOLUTE.

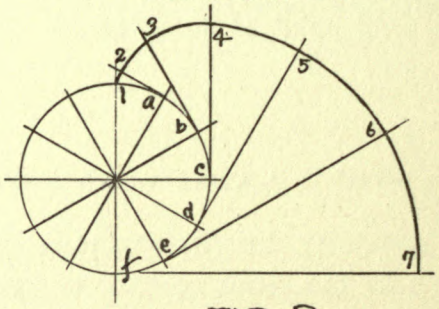


FIG. 3

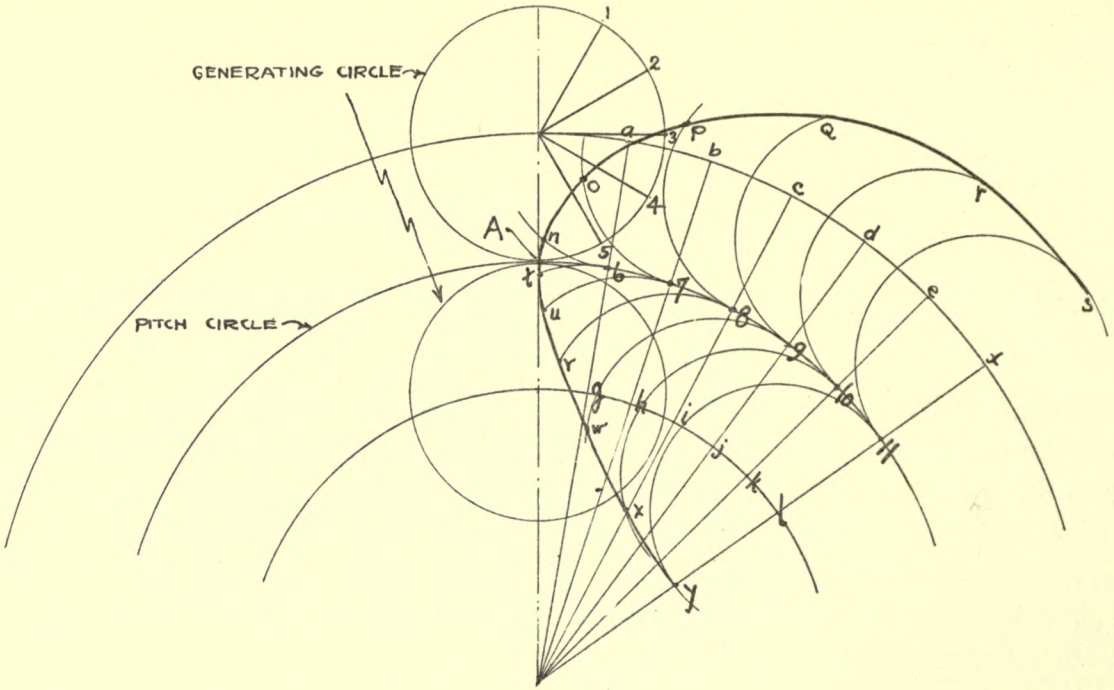
GEOMETRICAL CONSTRUCTION
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO. 60

PLATE 61. THE EPICYCLOID.

When a circle rolls round the edge of another circle instead of along a straight line the curve called the epicycloid is generated.

Draw the pitch circle, taking any convenient radius. (Take $4\frac{1}{2}''$ here.) Draw the generating circles of any diameter less than the radius of the pitch circle. Divide one of the generating circles into any number of equal parts, and starting at A lay off these divisions on the pitch circle. In this case take six on each side of A. Draw radial lines through these points of division and obtain a, b, c, d, e, and f. Taking a, b, c, d, e, and f, and also g, h, i, j, k, and l as centers, swing arcs using the radius of the generating circle. Take 6-n and 6-t equal to one division of the generating circle; 7-u and 7-o equal two divisions; and so on until the curve is complete. At the left construct another curve similar to the one given.

If the generating circle rolls inside of instead of outside of the pitch circle, the curve obtained is called the Hypocycloid.



THE EPICYCLOID

GEOMETRICAL CONSTRUCTION
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO. 61

PLATE 62.

Figure 1 is a representation of a "heart" cam. This type of cam is used when a movement both up and down is desired gradual and constant.

Draw the friction roller C in any convenient position. Draw the $5\frac{1}{2}''$ circle and assume that B is the maximum position of the center of the roller. Divide the distance from B to C into eight equal parts, and divide the $5\frac{1}{2}''$ circle into twice this number. Draw the radial lines through the points of division on the circumference. Set the compasses to the radius of the roller, and taking the intersections of the radial lines and the circles as centers, draw the dotted circles. Starting at A, draw the outline of the cam tangent to the circles. The right half of the cam is here drawn. The student is expected to complete the whole cam. This is to be inked.

Figure 2 shows a cam designed to produce a compound motion. Draw a circle of $5\frac{1}{2}''$ diameter, assume the lower position of the center of the roller to be at A, and divide the distance from A to B into six equal parts. The entire circumference is to be divided into twelve equal parts. Set the compasses to the radius of the roller, and draw the dotted circles as shown. Starting at C, draw the outline of the cam tangent to the dotted circles until the 270° line is reached. Divide the circumference from 270° to 330° into twelve equal parts, and draw radial lines through these points of division. Also divide E F into 12 equal parts and draw arcs through the points. The intersections of the arcs and the radial lines will give the points necessary for a gradual return from G to the starting point. In this particular cam the motion rises two spaces in 60°, rests for 30°, rises two more spaces in 60°, rests for 30°, rises two more spaces in 60°, rests for 30°, gradually returns towards original position in 60°, and rests for 30° before actually reaching there. This drawing is to be inked.

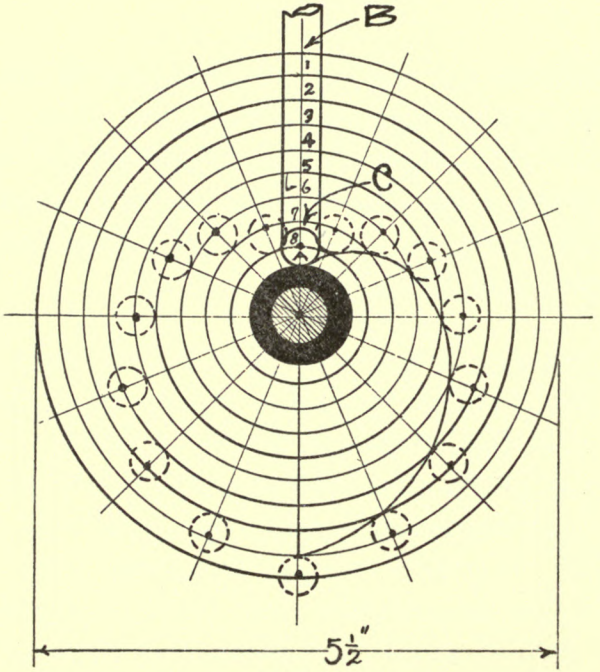


FIG. 1

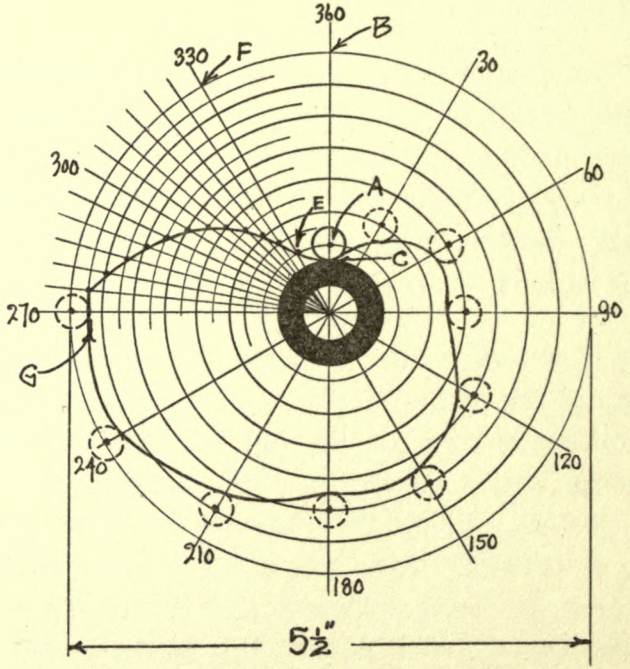


FIG. 2.

CAM DESIGN

SCALE FULL SIZE.

DRAWN BY

DATE

PLATE NO. 62.

GEARING FORMULÆ.

SYMBOLS		TO FIND		FORMULÆ
Diametral Pitch	= P	Diametral Pitch	P	$= \frac{3.1416}{P'}$
Circular Pitch	= P′	Circular Pitch	P′	$= \frac{3.1416}{P}$
Pitch Diameter	= D	Pitch Diameter	D	$= \frac{N}{P}$
Center Distance	= C	Center Distance	C	$= \frac{N+N_1}{2P}$
Addendum	= S	Addendum	S	$= \frac{P'}{3.1416}$
Dedendum	= d	Dedendum	d	= S
Clearance	= F	Clearance	F	$= \frac{0.157}{P}$
Thickness of Tooth	= T	Thickness of Tooth	T	= .48P′
Space between Teeth	= W	Space between Teeth	W	= .52P′
Outside Diameter	= O	Outside Diameter	O	$= \frac{N+2}{P}$
Number of Teeth	= N	Number of Teeth	N	= P × D
Length of Rack	= L	Length of Rack	L	= NP′

TEMPLET FOR GEAR TEETH.

When it is necessary to show the teeth in a complete gear wheel, it would require much time and labor to draw each tooth separately. This labor is saved by constructing an accurate pattern or templet of the proper tooth outline and tracing the outlines of the whole number of teeth in the gear from the pattern.

In constructing the templet, proceed as though drawing one tooth of the gear. The pitch, addendum, dedendum, and clearance circles are drawn, and the complete curve of one half the tooth laid out. Only one side of the tooth outline need be drawn, as in tracing around the templet in the finished drawing half the teeth are drawn first and the other half formed by turning the templet over with the reverse side uppermost. This makes the two sides of the teeth similar.

The templet is cut out in the form shown in the cuts illustrating the involute and cycloidal templets on the following pages. The divisions marking the tooth widths and spaces are laid off on the pitch circle of the finished drawing, and the templet pinned on with the center point at its lower end directly over the center of the pitch circle of the drawing. Then by revolving the templet the right sides of all the teeth are traced at the points already determined on the pitch circle. By reversing the templet the teeth are completed as described above.

The templet should, if possible, be cut from medium weight cardboard, as the clean-cut edge of the tooth outline will retain its proper shape longer when a large number of teeth are to be drawn. Sometimes the draftsman is called upon to draw gears of a certain definite size which have become standard in certain lines of work. The templets may then be constructed of some durable substance, such as hard rubber or celluloid, and filed away for future use.

TEMPLET FOR INVOLUTE TEETH. FIGURE 1.

(1) Draw the pitch, addendum, dedendum, and clearance circles. (2) Draw the perpendicular radius o a prolonged, intersecting the pitch circle at b. (3) Draw the line of obliquity x y through point b at an angle of 15° with the horizontal line b z. (4) With o as a center draw the base circle tangent to the line x y at the point c. (5) From c lay off to the left on the base circle the divisions c-1, c-2, c-3, etc., and to the right the divisions c-6, c-7, etc. These divisions should each be less than one tenth the diameter of the base circle. (6) At the points 1, 2, 3, 4, etc., draw the tangents to the base circle T_1-1, T_2-2, T_3-3, etc. (7) Using the radius c b with point c as center, draw the tooth curve as far as the first tangent T_1 from b, thus giving point d on tangent T_1. (8) Taking the next radius c d, the curve is continued to the next tangent T_2, giving point e. (9) By successively using the remaining radii, c e, c f, etc., the curve is carried a little beyond the outside or addendum circle. (10) The lower part of the tooth curve between the pitch and base circles is obtained by using the radii c b, c k, and c n. (11) The tooth edge below the base circle is radial to center o, and the fillet joining the side of the tooth to the whole depth or clearance circle is drawn with a radius equal to one seventh the distance between two adjacent teeth taken on the addendum circle.

INVOLUTE RACK WITH STRAIGHT FLANKED TEETH. FIGURE 2.

(1) Draw the addendum, pitch, dedendum, and clearance lines. (2) From a lay off the linear pitch a b which corresponds to the circular pitch in circular gears. (3) Then after locating point c, which gives the tooth width, draw all left-hand sides of the teeth, such as d e, through the pitch points at an angle of 75° with the pitch line. (4) The right-hand edges of the teeth are also drawn at 75° from the pitch line, but in the opposite direction of obliquity. (5) The fillets at the bottom of the space are drawn with a radius equal to one seventh of the distance between two adjacent teeth measured on the addendum line.

TEMPLET FOR CYCLOIDAL TEETH. FIGURE 3.

(1) Draw all gear circles as in the drawing of the involute templet. (2) Draw radius o a intersecting pitch circle at point b. (3) From b lay off on the pitch circle the divisions b-1, b-2, b-3, etc., to the right, and b-7, b-8, b-9, etc., to the left. (4) From points 1, 2, 3, 4, etc., draw the internally radial lines to the pitch circle, and from points 7, 8, 9, etc., draw the externally radial lines to the pitch circle. (5) With a radius less than one half the radius of the pitch circle, and with r_1 as a center, draw the first internal generating circle p c tangent to the pitch circle at point 1. (6) With the same radius, and with the points r_2, r_3, r_4, etc., as centers, draw the other internal generating circles. (7) The external generating circles are drawn with the same radius from points r_7, r_8, etc. (8) Set the dividers at the distance b-1 on the pitch circle, and from point 1 lay off this distance b-1 on the first generating circle p c. (9) On the next generating circle lay off two divisions, each equal to b-1, from point 2. (10) On the next generating circle lay off three divisions, each equal to b-1, from point 3. (11) Continue to lay off these divisions on the generating circles until they pass below the clearance circle. (12) The points d, e, f, g, give the direction of the tooth curve between the pitch and clearance circles. (13) Using the same length, b-1, step off one division from point 7 on the first external generating circle. (14) By laying off two divisions from point 8 and three divisions from point 9 we get the points h, k, m, and n, which give the direction of the upper part of the tooth curve. (15) Connecting points n, m, k, h, b, d, e, f, and g, the whole curve of the tooth is obtained. (16) The fillet at the bottom of the curve is drawn with a radius equal to one seventh the distance between two adjacent teeth measured on the addendum circle.

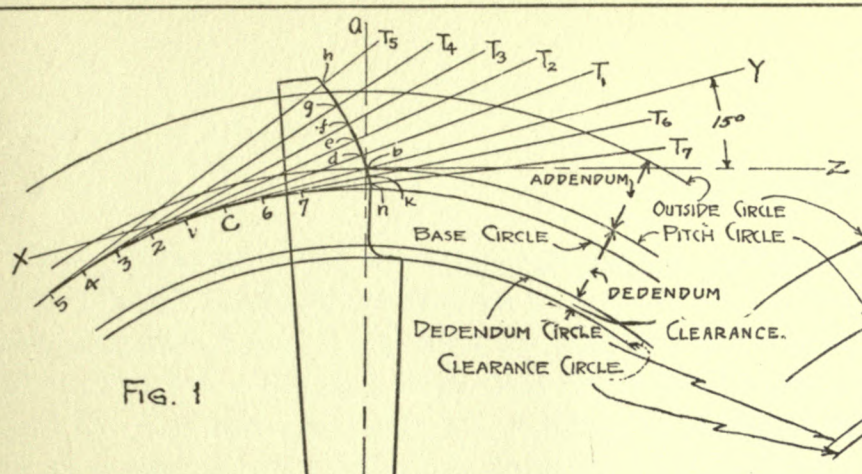


FIG. 1

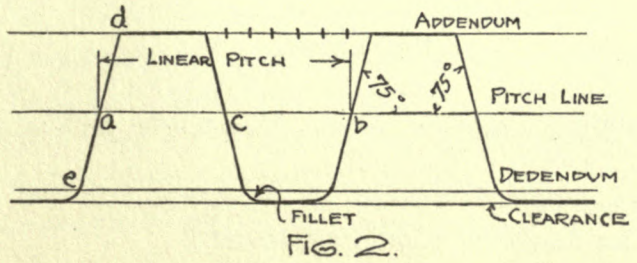


FIG. 2.

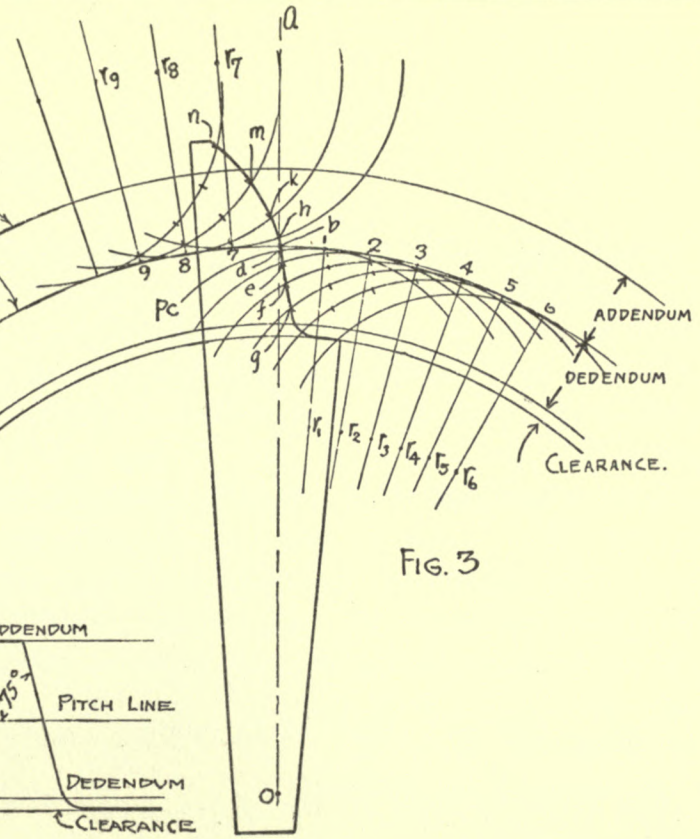


FIG. 3

TEMPLET CONSTRUCTION

PLATE 63.

Draw a spur gear of 22 teeth, 3″ circular pitch. Use the involute method.

PLATE 64.

Draw a spur gear of 24 teeth, 1 diametral pitch. Use the cycloidal method.

PLATE 65.

Draw a rack and pinion of 18 teeth, 2″ circular pitch. Use either method.

(The complete gear in the above problems cannot be constructed to full scale. If full scale is used, draw as much of the gear as possible. These drawings should be inked.)

BEVEL GEARS.

The method of laying out bevel gear blanks is shown in Figure 4. (1) Draw the center lines of gear shafts A B and C D 90° apart and intersecting at point O. (2) From O measure down on line C D a distance of one half the pitch diameter of gear Y and draw the pitch line E F of gear X parallel to the line A B. (3) From O measure to the left on line A B a distance of one half the pitch diameter of gear X and draw pitch line G H of gear Y parallel to line C D. The two pitch lines will intersect at point J. (4) From K on line A B measure off the distance J K on line G H locating point M. This gives the pitch diameter J M of gear Y. (5) From L on line E F measure off the distance J L locating point N. This gives the pitch diameter J N of gear X. (6) Draw the front cone pitch lines O M, O J, and O N. (7) Through M and perpendicular to O M draw the back cone line M P, and from point P perpendicular to O J draw the back cone lines J P and J Q. By drawing a line from Q through point N the last back cone line Q N is obtained. (8) From M lay off the addendum distance M-1, the dedendum distance M-2, and the clearance 2-3. (9) These distances are also laid off from points J and N, giving points 4, 5, 6, 7, 8, 9, and 10. (10) Draw the lines O-1, O-2, O-3, O-4, O-5, O-6, O-7, O-8, O-9, and O-10. (11) The length of the tooth face 1-12 is made about one third the length of the front cone line O-1. (12) The proportions of such details as the thickness of metal in the gears, the length of the hubs, and the diameters of the shaft bores, are left to the student to design. The cross-sectioned portions show where the metal would be cut if a plane were passed through the two gears.

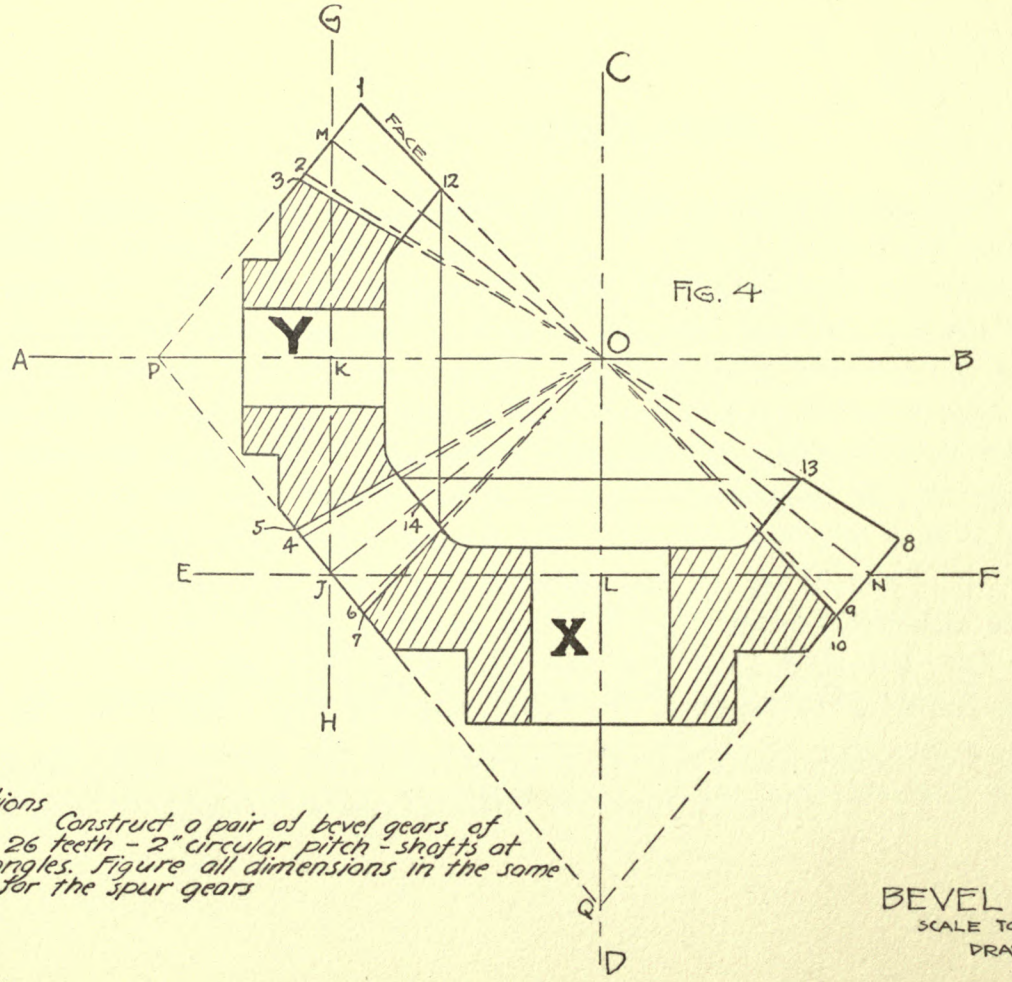


FIG. 4

Instructions

Construct a pair of bevel gears of 24 and 26 teeth - 2" circular pitch - shafts at right angles. Figure all dimensions in the same way as for the spur gears

BEVEL GEAR.

SCALE TO BE DETERMINED

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PLATE NO. 66

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ISOMETRIC PROJECTION.

Isometric projection is a method of drawing by means of which a pictorial effect can be obtained without destroying the relative proportions of the several parts of the object. Measurements taken on the vertical or thirty degree lines of an isometric drawing are in their true length. No dimensions should be taken on any other lines than these.

When drawing the plates numbered 67, 68, 69, and 70, draw the top and front views as given and dimension them. Place no dimensions or letters on the isometric. These are given here merely to show the connection between the two types of projection (Orthographic and Isometric).

All isometric drawings are to be inked.

Instructions Draw a 3" cube as shown in Fig 1. Note how the isometric view of a circle is obtained by drawing lines to the middle points of the sides from the opposite corners and taking the intersections as centers. If it is ever necessary to obtain a surface such as ABCD standing out from another surface, draw this surface on the latter as EFGH, and project out 30° from each corner of EFGH the required distance. The construction of the cone in Fig. 2 should need no explanation.

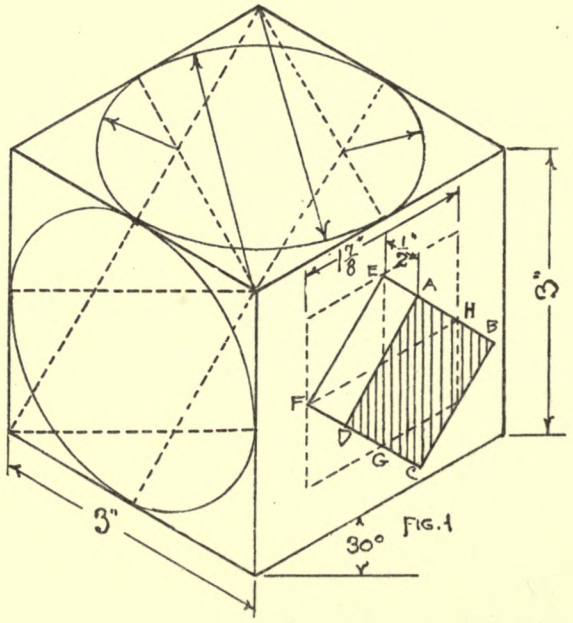


FIG. 1

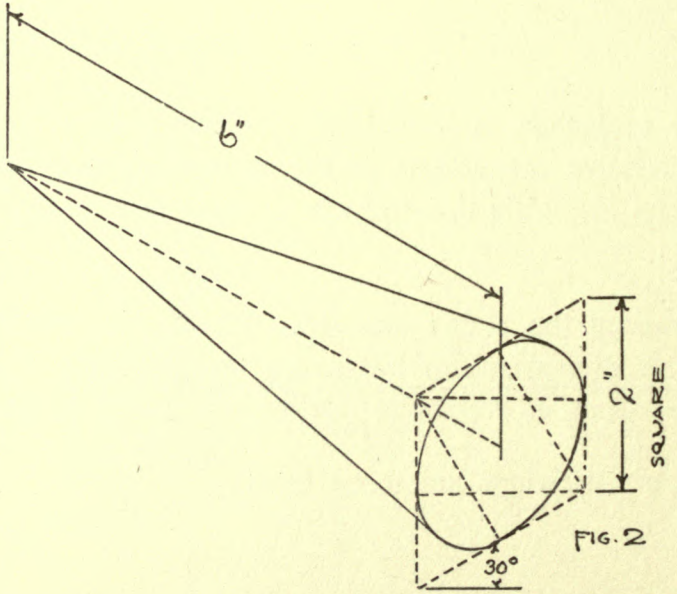
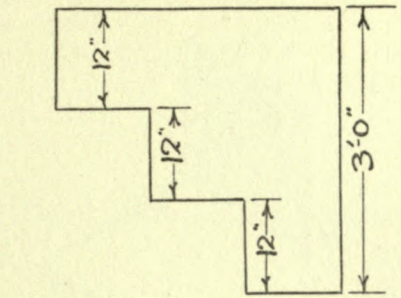
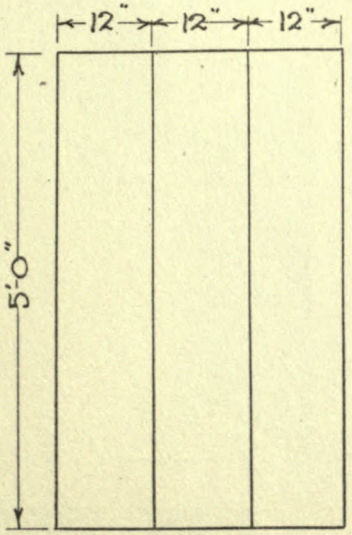
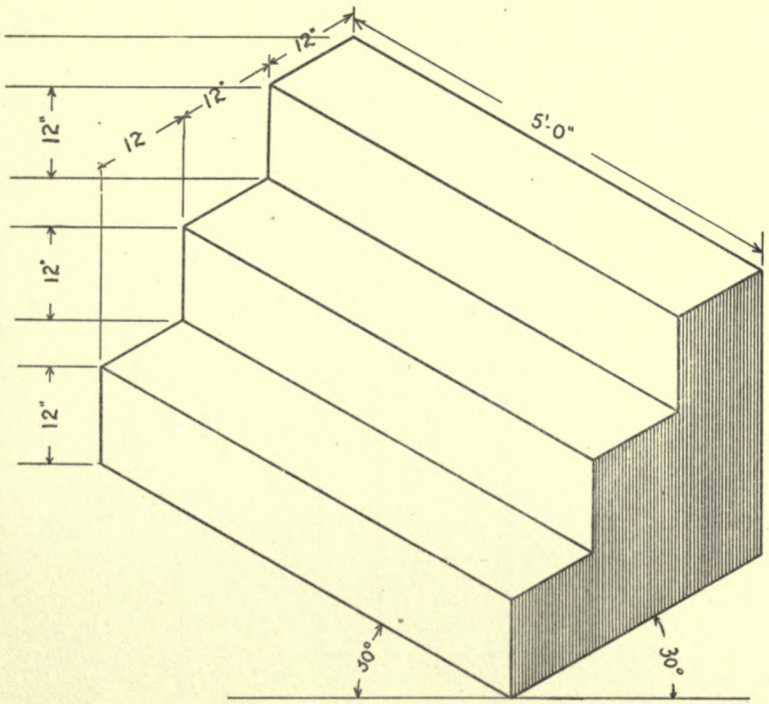


FIG. 2

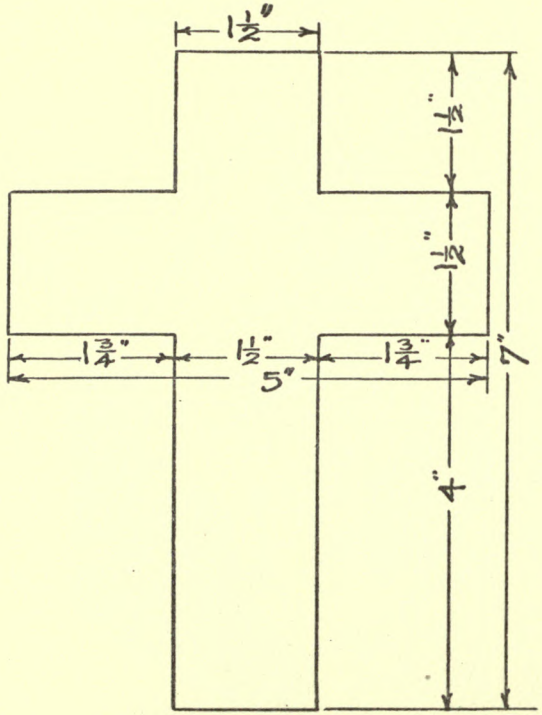
ISOMETRIC PROJECTION
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO. 67

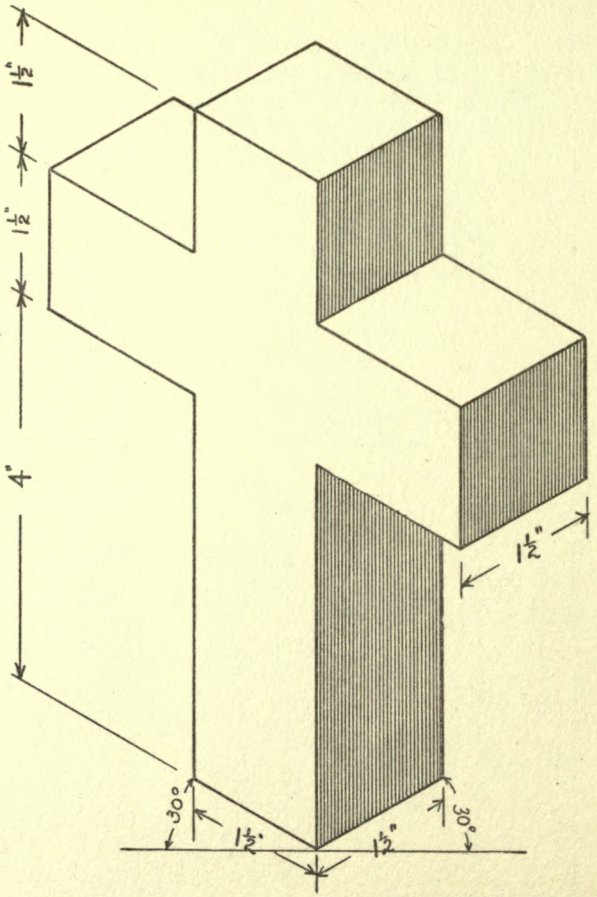




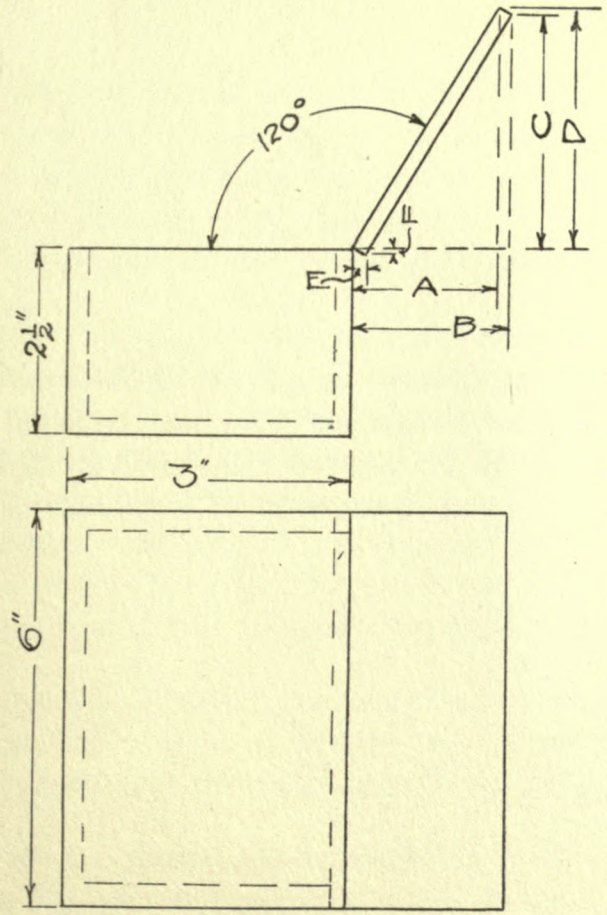


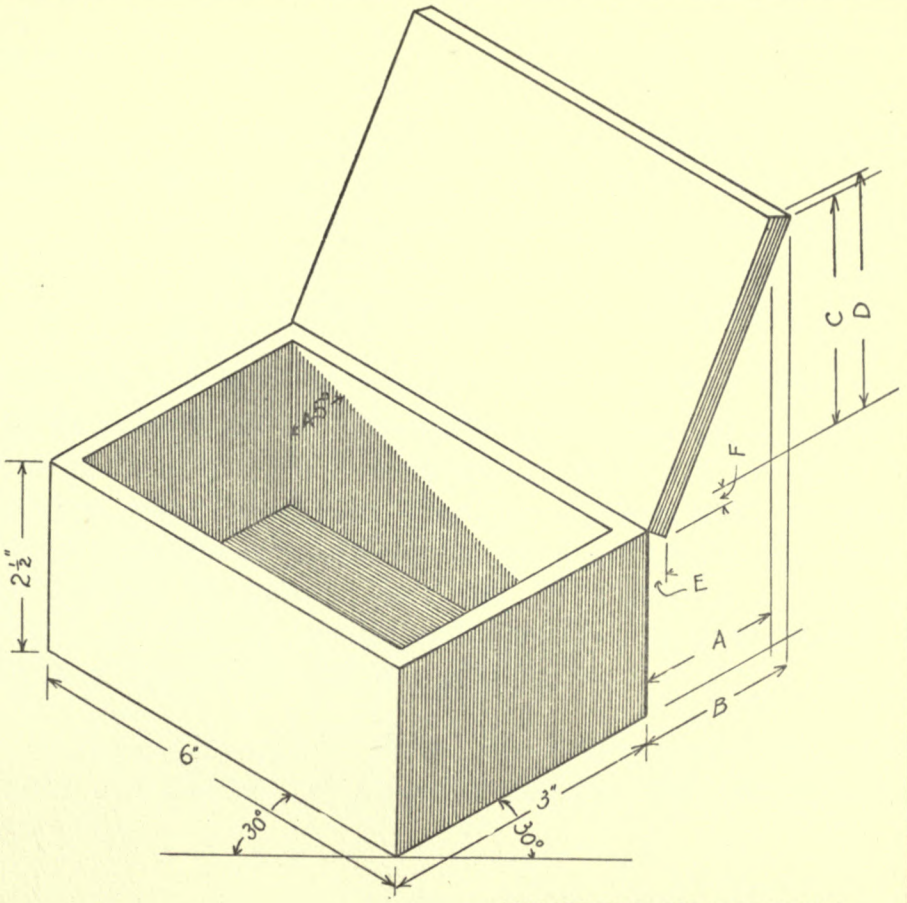
ISOMETRIC PROJECTION
SCALE 1" = 1 FOOT
DRAWN BY
DATE
PLATE NO. 68





ISOMETRIC PROJECTION
SCALE FULL SIZE
DRAWN BY
DATE.
PLATE. NO. 69





ISOMETRIC PROJECTION
SCALE FULL SIZE
DRAWN BY
DATE
PLATE NO. 70

PLATE 71.

For this, the final isometric drawing, lay out a sheet whose outside dimensions are 20½″ x 29″ with a border of 1¼″. On this sheet make an isometric drawing of some fairly complicated machine. The one made on Plate 58 is suggested. The measurements may be taken directly from this with the dividers and transferred to the isometric. Make all letters with the instruments. Make the drawing on white paper (" Whatman's " is suggested) and ink it.

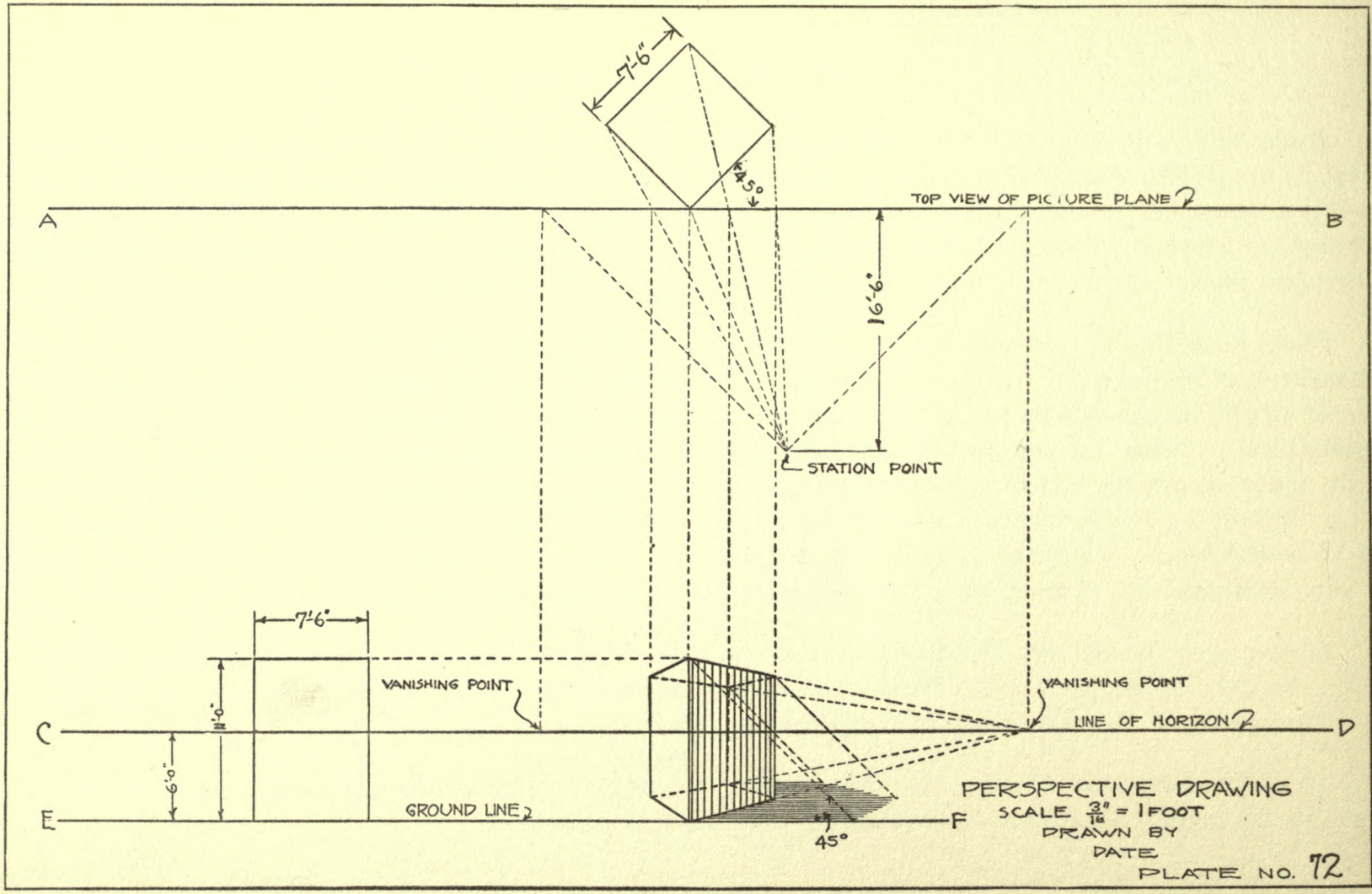
PERSPECTIVE DRAWING.

If one were to look out of the window at a building, and if a line could be drawn from every point of the building to the eye of the observer, the points on the window where the lines pierced it would be the ones to be connected if a picture of the building was to be drawn upon the window. The window corresponds to the picture plane in perspective drawing — the plane upon which the observer and object rest is the horizontal plane called the ground — the plane parallel to the ground and passing through the eye of the observer is the plane of horizon.

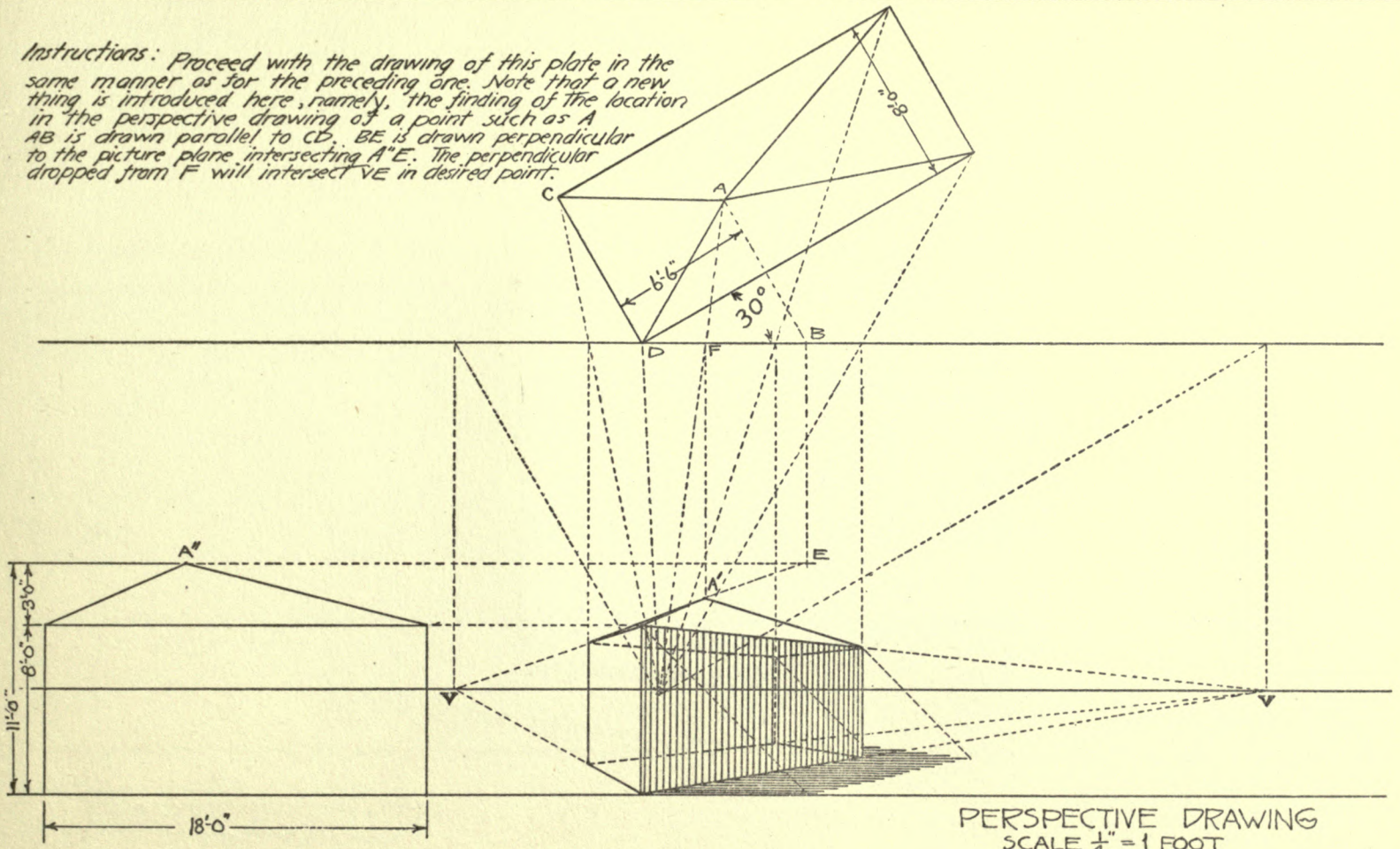
Study Plate 72 very carefully and note the following: A B is a top view of the picture plane — C D is a front view of the plane of horizon — E F is a front view of the ground plane. The station point (the point at which the observer stands) is usually taken at about one and one half the height of the object in front of the picture plane. This point must be selected to show the object to the best advantage. The line of horizon is generally taken from five to six feet above the ground. Note that the vanishing points are obtained by drawing lines from the station point parallel to the faces in the top view until they intersect the picture plane, and then dropping perpendiculars to the line of horizon. Note how lines are drawn from each point of the object in the top view to the station point and perpendiculars, then dropped from the intersections of these lines with the picture plane.

Obviously, in reality, the object would never be against the picture plane. Plates 72 and 73 show it in this position, but this is done so that the student will master the principles of perspective easier. The remaining plates are to be drawn with the object away from the picture plane.

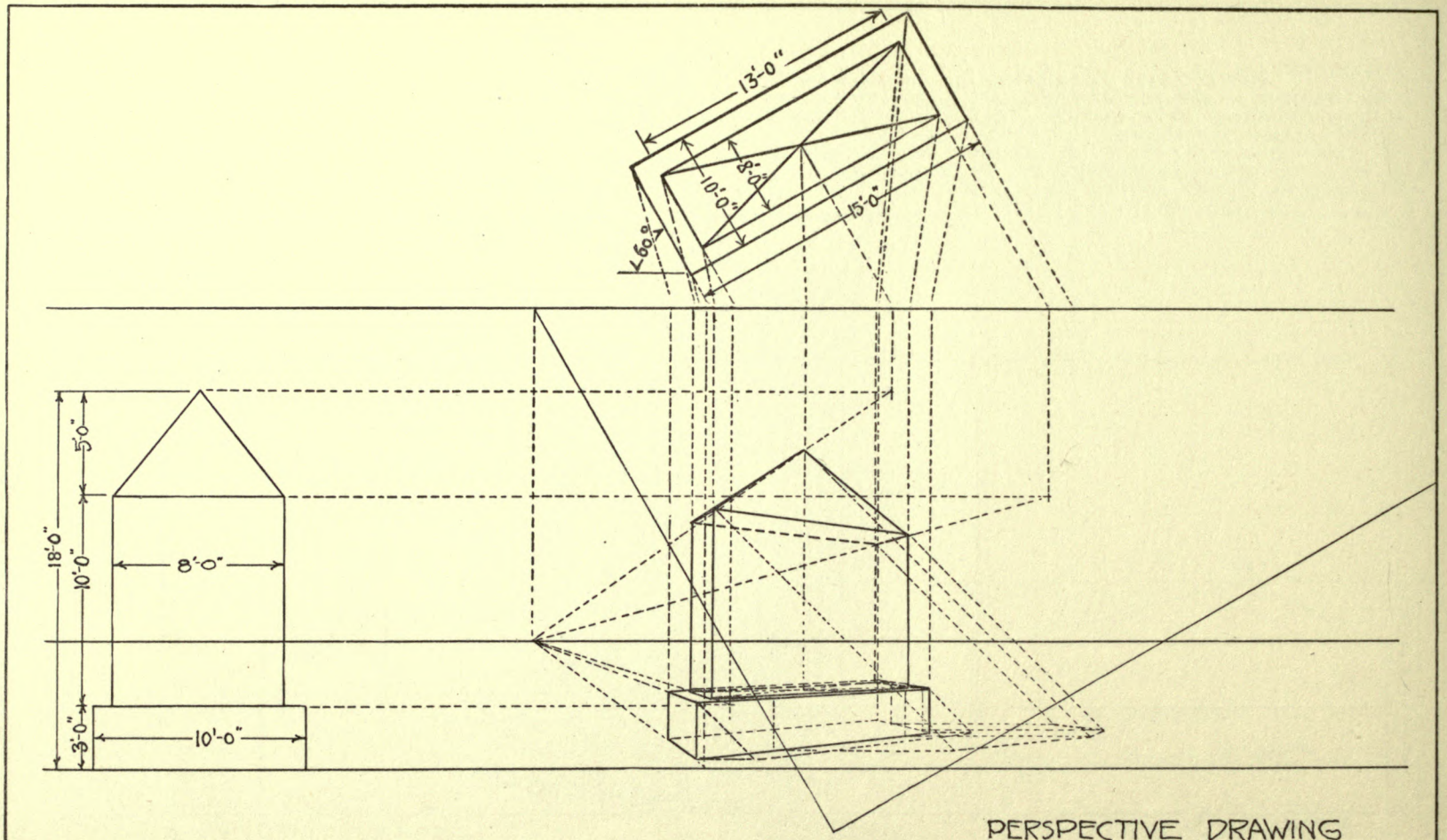
All of the perspective drawings are to be inked and shaded. If all dotted and construction lines are drawn in red ink the general appearance of the drawing will be greatly improved.


7'-6"
45°
TOP VIEW OF PICTURE PLANE
A
B
16'-6"
STATION POINT
7'-6"
VANISHING POINT
VANISHING POINT
LINE OF HORIZON
C
D
1'-0"
6'-0"
E
GROUND LINE
F
45°
PERSPECTIVE DRAWING
SCALE 3/16" = 1 FOOT
DRAWN BY
DATE
PLATE NO. 72

Instructions: Proceed with the drawing of this plate in the same manner as for the preceding one. Note that a new thing is introduced here, namely, the finding of the location in the perspective drawing of a point such as A. AB is drawn parallel to CD. BE is drawn perpendicular to the picture plane intersecting A"E. The perpendicular dropped from F will intersect VE in desired point.

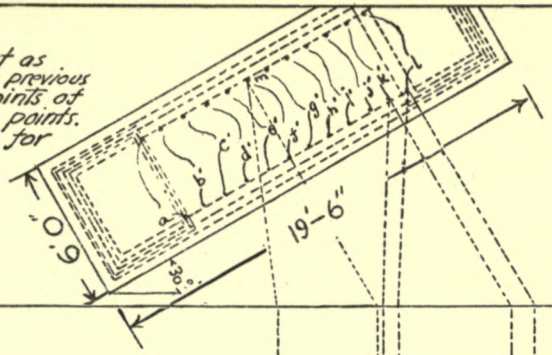


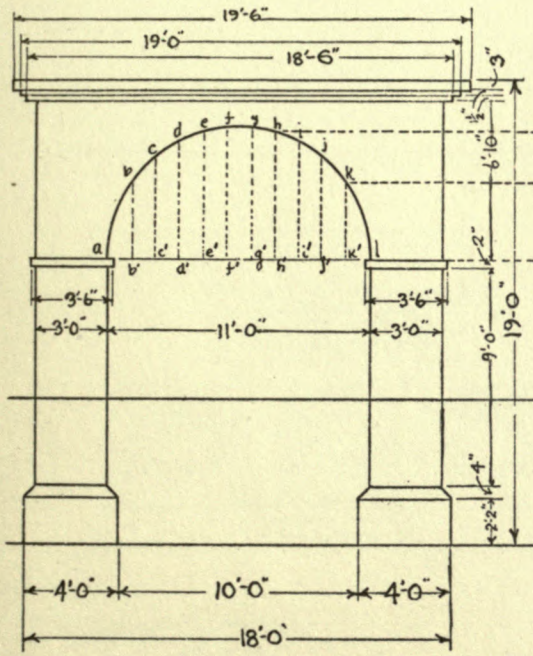
PERSPECTIVE DRAWING
SCALE $\frac{1}{4}$" = 1 FOOT
DRAWN BY
DATE
PLATE NO. 73

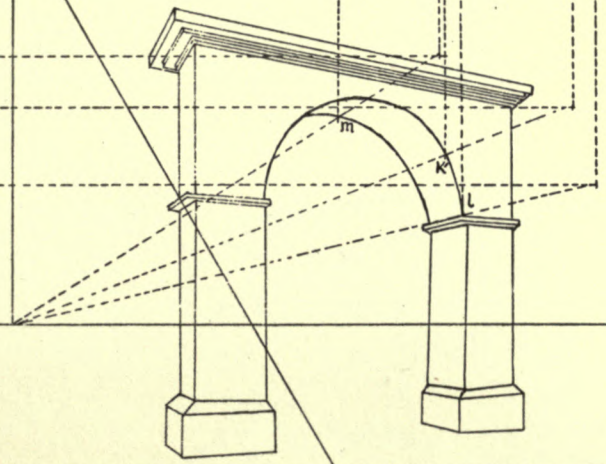


PERSPECTIVE DRAWING
SCALE $\frac{1}{4}$" = 1 FOOT
DRAWN BY
DATE
PLATE NO. 74

Instructions Draw the front and top views of the object as shown. All points in the perspective are obtained as in the previous drawing and attention is called to the fact that the points of the curve are obtained in the same manner as other points. The drawing of the shadow is left as an exercise for the student.

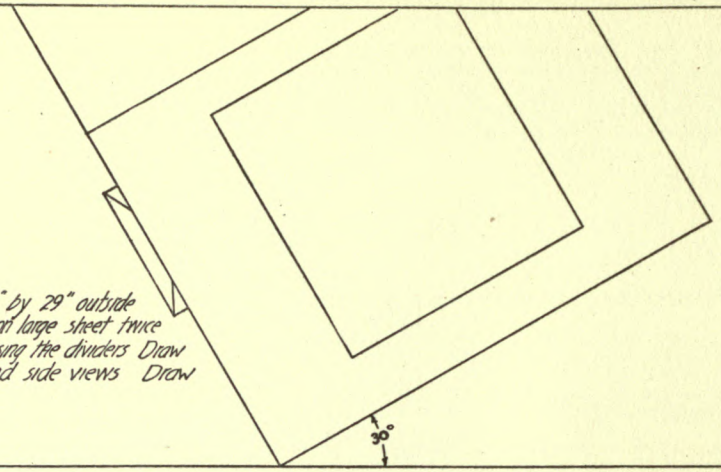


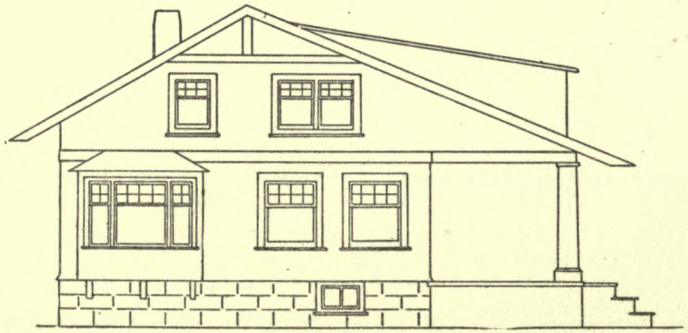


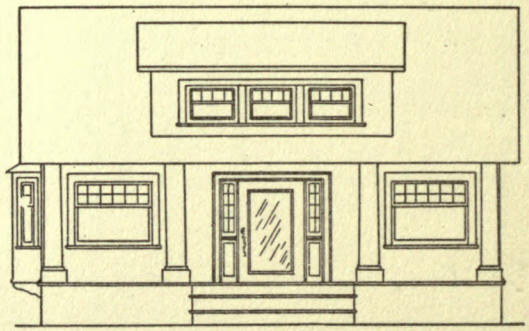


PERSPECTIVE DRAWING
SCALE $\frac{1}{4}$" = 1 FOOT
DRAWN BY
DATE
PLATE NO. 75

Instructions Size of sheet to be 20½" by 29" outside dimensions - 1" border Make drawing at large sheet twice the size given here Transfer distances using the dividers Draw the perspective between the front and side views Draw the shadow







PERSPECTIVE DRAWING
DRAWN BY
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PLATE NO. 76

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